Catch, Escapement, and Exploitation of Pink Salmon in British Columbia, 951 - 1981

rry D. Beacham

epartment of Fisheries and Oceans
isheries Research Branch
acific Biological Station
Nanaimo, British Columbia V9R 5K6

May 1984

Canadian Technical Report of
Fisheries and Aquatic Sciences
No. 1276

84- 4425 /

Canadian Technical Report of Hydrography and Ocean Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. The subject matter is related generally to programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out of stock reports will be supplied for a fee by commercial agents.

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications is published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 39: Index to Publications 1982. The current series, which begins with report number 1, was initiated in January 1982.

Rapport technique canadien sur l'hydrographie et les sciences océaniques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Le sujet est généralement lié aux programmes et intérêts du service des Sciences et levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact parait au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Les établissements des Sciences et levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Une liste complète de ces publications figure dans le volume 39, Index des publications 1982 du *Journal canadien des sciences halieutiques et aquatiques*. La série actuelle a commencé avec la publication du rapport numéro 1 en janvier 1982.

Canadian Technical Report of
Fisheries and Aquatic Sciences No. 1276

May 1984

CATCH, ESCAPEMENT, AND EXPLOITATION OF PINK SALMON IN BRITISH COLUMBIA, 1951-1981

by

Terry D. Beacham

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

(c) Minister of Supply and Services Canada 1984

Cat. No. Fs 97-6/1276E ISSN 0706-6457

Correct citation for this publication:

Beacham, T. D. 1984. Catch, escapement, and exploitation of pink salmon in British Columbia, 1951-1981. Can. Tech. Rep. Fish. Aquat. Sci. No. 1276: 215 p.

TABLE OF CONTENTS

Page
ABSTRACT v

INTRODUCTION 1

MATERIALS AND METHODS 1

RESULTS 2
  REGIONAL COMPARISONS OF CATCH AND ESCAPEMENT 2
  NORTH AND CENTRAL COAST 3
  SOUTH COAST 4
  ASSESSMENT OF MAJOR PINK SALMON STOCKS 4
    Queen Charlotte Islands (Statistical Areas 1-2) 4
      Catch and Escapement 4
      Stock and Recruitment 5
        Odd Years 5
        Even Years 5
    North Coast (Statistical Areas 3-5) 6
      Catch and Escapement 6
      Stock and Recruitment 6
        Odd Years 6
        Even Years 7
    Central Coast (Statistical Areas 6-10) 7
      Catch and Escapement 7
      Stock and Recruitment 8
        Odd Years 8
        Even Years 8
    Johnstone and Georgia Strait (Statistical Areas 11-18, 28). . . . 9
      Catch and Escapement 9
      Stock and Recruitment 9
        Odd Years 9
        Even Years 10
    Juan de Fuca Strait (Statistical Areas 19-20) 10
    West Coast of Vancouver Island (Statistical Areas 21-27) . . . 10
      Catch and Escapement 10
      Stock and Recruitment 11
    Fraser River 11
      Catch and Escapement 11
      Stock and Recruitment 11

DISCUSSION 12

ACKNOWLEDGMENTS 13

REFERENCES 14

TABLES 16

FIGURES 33

APPENDIX A 123

TABLE OF CONTENTS

page

APPENDIX B 153

APPENDIX C 185

ABSTRACT

Beacham, T. D. 1984. Catch, escapement, and exploitation of pink salmon in British Columbia, 1951-1981. Can. Tech. Rep. Fish. Aquat. Sci. No. 1276: 215 p.

Catch, escapement, exploitation, and stock-recruitment relationships were investigated for major stocks of British Columbia pink salmon. On a coastwide basis, catch and escapements of pink salmon have tended to increase during 1951-1981. Annual exploitation rates were usually between 50 and 70% during 1951-1981. Catch by the purse seine fleet has usually been between 55 and 75% of the total catch. The gillnet share of the total catch has declined from in excess of 30% in the 1950s to less than 15% after 1978. The troll shore of the catch has increased from less than 2% before 1956 to in excess of 15-20% after 1978. Gillnetters account for a higher portion of the catch in northern fisheries than in southern ones. Exploitation rates in the northern fisheries were approximately 60% annually during 1951-1981. Exploitation rates have increased in southern fisheries from about 50% annually in the mid-1960s to almost 70% after 1978. Escapements for all odd-year stocks other than the North Coast one are less than the apparent optimum. Escapements for most even-year stocks are at or above apparent optimum levels. Maximum sustained yield from British Columbia pink salmon stocks is estimated at 15.0 million pieces in the odd-year line and 11.5 million pieces in the even-year line.

Key words: British Columbia, catch, escapement, exploitation, pink salmon, stock-recruitment

RÉSUMÉ

Beacham, T. D. 1984. Catch, escapement, and exploitation of pink salmon in British Columbia, 1951-1981. Can. Tech. Rep. Fish. Aquat. Sci. No. 1276: 215 p.

L'auteur présente les résultats d'une étude sur les prises, les échappées, l'exploitation et les relations stock-recrutement dans le cas des principaux stocks de saumon rose de la Colombie-Britannique. Sur toute la côte, les prises et les échappées ont augmenté, entre 1951 et 1981, tandis que les taux d'exploitation annuelle variaient de 50 à 70 %. D'une façon générale, la flottille de senneurs s'est appropriée de 55 à 75 % de la prise totale. Les captures aux filets maillants, qui dépassaient 30 % de la prise totale durant les années 1950, ont chuté à moins de 15 % après 1978. Pour ce qui est de la pêche à la ligne traînante, les prises sont passées de moins de 2 % avant 1956 à plus de 15-20 % après 1978. Les saumons capturés à l'aide de filets maillants constituent un plus grand pourcentage de la prise dans les pêcheries du nord que dans celles du sud. Dans les premières, les taux d'exploitation s'élevaient à environ 60 % annuellement, entre 1951 et 1981, tandis que, dans les secondes, ils sont passés d'environ 50 % par année vers le milieu des années 1960 à presque 70 % après 1978. Les échappées pour tous les stocks d'années impaires, sauf celui de la côte nord, sont inférieures à l'optimum apparent tandis que celles de la plupart des stocks d'années paires atteignent ou dépassent les niveaux optimums apparents. On évalue le RMS des stocks de saumon rose de la Colombie-Britannique à 15 millions de poissons pour la lignée d'années impaires et à 11,5 millions pour la lignée d'années paires.

Mots-clés: Colombie-Britannique, prise, échappée, exploitation, saumon rose, stock-recrutement.

INTRODUCTION

Spawning populations of pink salmon (Oncorhynchus gorbuscha) are widespread in North America and Asia, with their Pacific and Arctic Ocean distributions outlined by Takagi et al. (1981). In North America, they have also been successfully introduced into the Great Lakes (Kwain 1982). Pink salmon in the Pacific Ocean all mature at two years of age, so that the even- and odd-year broodlines do not interbreed. Genetic differences are therefore greater between broodlines than among stocks within a broodline (Aspinwall 1974). Ricker (1962) reviewed possible mechanisms that could account for the absence of one broodline in areas where the other broodline is present.

There are extensive commercial fisheries in British Columbia that harvest pink salmon. Hoar (1951) has summarized the catch statistics of the British Columbia pink salmon fishery up to 1949. In 1951, coastal British Columbia was divided into a number of statistical areas (Fig. 1), and records have been kept of the catch of pink salmon by statistical area and gear type. However, the system of data collection has not been perfect, and deficiencies of the system have been discussed by Healey (1982) and Wong (1983).

If pink salmon stocks are to be managed for escapements to be at optimum levels and catch to be at maximum levels, then the status of major stocks in British Columbia must be evaluated so that levels of exploitation and stock size that maximize catch on a continuing basis can be determined. This report examines catches, escapements, exploitation, and stock assessments of major stocks of pink salmon in British Columbia.

MATERIALS AND METHODS

Catch information by statistical area and gear was derived by methods similar to those outlined by Wong (1983). No adjustments were made in the catch data for contribution of pink salmon of United States origin in the catch, nor for pink salmon of British Columbia origin in United States catches. No adjustments in the catch data were made for Native Indian subsistence catch, nor for any sport catch.

Pink salmon spawning escapements have been recorded by Fishery Officers and Guardians and these data are the estimate used for annual escapement by statistical area. Test-fishing and mark-recovery studies may also be used to estimate escapements (e.g. Fraser River). It was assumed that escapement counts are equally reliable from 1951 to 1981 and no adjustments were made to the estimated escapements. Escapements presented in the study were derived from original spawning ground reports and have not been adjusted in any manner.

Stock-recruitment curve of the type

$$R = Se^{a(1-S/B)} \qquad (1)$$

where R = number of returning adults for a broodyear
S = spawning stock size that produced returns
B = replacement stock size

were fitted to the catch and escapement data.

Stock-recruitment curves were fit to even-numbered and odd-numbered broodyear for each major stock if possible. The parameters a, B, and mean square residual (σ^2) were derived by the linear regression on ln (R/S) on S. Optimum exploitation rates were determined by projecting cumulative catches between 1960 to 2020 and using separate stock-recruitment relationships for even- and odd-numbered broodyears. Cumulative catch was tabulated for exploitation rates of 0 to 100% in increments of 1%. For each exploitation rate and each year, the resulting recruitment from that particular escapement was the average of 100 simulations, one simulation being of the form

$$\ln (R/S) = a + \frac{a}{B} S + V \qquad (2)$$

where V is a random normal deviate of mean 0 and standard deviation σ

(i.e. square root of residual mean square). Equation 2 was therefore

evaluated 100 times with random values of V, subject to a normal distribution and standard deviation of σ. The average recruitment was then determined, and used subsequently in the projection. Cumulative yield versus exploitation rate were then plotted for the 60-year projections.

Once an optimum exploitation rate had been identified, projections were conducted for some stocks for the period 1960-1987 at a yearly exploitation rate identified as optimum. Observed returns for 1960 or 1961 were the starting points in the projection. This projection allowed the current status of the stock to be determined if a policy of a constant annual exploitation rate had been implemented in 1960 or 1961.

RESULTS

REGIONAL COMPARISONS OF CATCH AND ESCAPEMENT

The catch of pink salmon in British Columbia fisheries has ranged between 3.5 and 23.4 million pieces annually (Fig. 2, Table 1). The catch exceeded 15 million pieces in 1962, 1966, 1968, and 1981. Catches increased considerably during 1975-1981 from less than 5 million to in excess of 18 million pieces. Escapement of pink salmon during 1960-1981 have been relatively stable at approximately 7 million fish. Fraser River pink salmon escapements are not available before 1957, and this accounts for the lower levels of escapements in odd-numbered years in the 1950s. Exploitation rates have been, on average, about 60% since 1957 (Fig. 3). Exploitation rates were in excess of 70% in 1966 and 1967. Exploitation rates in excess of 70% in 1951, 1953, and 1955 are an artifact of not including Fraser River pink salmon escapements for those years in the analysis.

Purse seiners account for the major portion of the catch in British Columbia fisheries (Fig. 4). The purse seine portion of the catch has, on average, been about 65-70% of the total annual catch since 1951 (Fig. 5). Since 1960, the gillnet portion of the catch has declined from in excess of 35% of the total catch to about 10% in 1981. The troll portion of the catch has increased from less than 2% before 1955 to above 25% in 1981. Catch-per-unit effort of the troll fleet has increased substantially in 1977, 1979, and 1981 (Table 2). Catches for each gear in each statistical area are illustrated in Appendix 1.

The total British Columbia catch of pink salmon was examined on a regional basis. The catch in the northern fisheries was significantly larger than in the southern fisheries in the 1960s (Fig. 6). In even-numbered years, the northern fisheries comprised in excess of 75% of the total British Columbia pink salmon catch (Fig. 7). In odd-numbered years, the northern fisheries usually comprised at least 25% of the total catch. The fishery off the west coast of Vancouver Island has comprised about 15% of the total British Columbia pink salmon catch in odd-numbered years. This has been coincident with the increasing share of the catch accounted for by the troll fleet. Catch by statistical area by year is illustrated in Appendix 2 and annual escapements are illustrated in Appendix 3. The catch and exploitation portion will now be compared on a regional basis.

NORTH AND CENTRAL COAST

Catches in the North and Central Coast regions are greater in even-numbered years than in odd-numbered ones. The catch in 1962 was about 22 million pieces, and was generally in excess of 10 million pieces in even-numbered years during 1962-1972 (Fig. 8). Catch and escapement of odd-numbered broodyears were lower in 1967 and 1969 than in other years during 1951-1981. Escapements have generally been declining since the 1962 level of nearly 10 million fish (Fig. 8). The 1981 escapement was about 3 million fish.

Exploitation rates in the North and Central Coast fisheries have usually been about 60% annually, but they have exceeded 60% since 1977 (Fig. 9). Exploitation rates were usually greater in even-numbered years than in odd-numbered ones.

Since 1971, purse seiners have been the gear accounting for the majority of the catch in the North and Central Coast fisheries (Figs. 10,11). Before 1960, the gillnet and seine portions of the catch were, on average, about equal. The gillnet share of the catch has declined from about 50%

during 1951-1960 to about 20% during 1978-1981. Purse seiners accounted for in excess of 65% of the catch during 1978-1981.

SOUTH COAST

Catches in the South Coast region are greater in odd-numbered years than in even-numbered ones. They have exceeded 10 million pieces in only 1981 (Fig. 12). Catches have been increasing in odd-numbered years in the South Coast region since 1975. Escapements have also been increasing during the same period and this can be attributed to the increasing stock size of Fraser River pink salmon. Escapements before 1957 were not available for the Fraser River pink salmon stock, and thus exploitation rates in excess of 80% are an artifact. Exploitation rates have usually been in excess of 60% since 1976 (Fig. 13).

Purse seiners are the dominant gear the South Coast fishery, and they usually account for 65-70% of the catch (Fig. 14,15). The troll portion of the catch has increased since 1957, and in 1969 and 1977 was equal to the purse seine share. The catch by gillnetters declined during 1966-1979 and during this period their share of the catch declined to less than 5% of the total.

The previous results have indicated that pink salmon in northern and southern British Columbia have been harvested at different rates and have shown same different trends in each and escapement. The major pink salmon stocks of British Columbia will now be considered in detail in terms of catch, escapement, and stock assessment.

ASSESSMENT OF MAJOR PINK SALMON STOCKS

Queen Charlotte Islands (Statistical Areas 1-2)

Catch and escapement

Catch in the odd-numbered years was usually less than 100 thousand pieces annually during 1959-1975, but increased subsequently to in excess of 700 thousand pieces in 1981 (Fig. 16). Catch in the even-numbered years has been variable, but it was usually in excess of 500 thousand pieces. Escapements of pink salmon in odd-numbered years have declined since 1969 (Table 3), so that by 1981 the escapement was about 13 thousand fish. Escapements in even-numbered years after 1972 were about only 60% of the levels during 1966-1972.

Exploitation rates have apparently increased subsequent to 1970 (Fig. 17). Exploitation rates in odd-numbered years were in excess of 90% since 1977, but catches were probably not derived from the Queen Charlotte Islands stock. There are interceptions in this fishery (Hollett 1970), and the period during which catches have increased suggests that Fraser River, Skeena River, and Alaskan pink salmon were intercepted in this fishery. Accordingly, production information for the 1975-1979 broodyears were not used in the stock-recruitment analysis. A similar rationale was used for excluding the 1955 broodyear (Table 3).

The fishery is conducted primarily by purse seiners, although catch by trollers in 1980 and 1981 was greater than that of purse seiners (Figs. 18,19). The gillnet portion of the catch has been less than 5% since 1976. The troll catch in 1980 was 825 thousand pieces, 80% of the catch from the Queen Charlotte Islands fishery in that year. This catch may have contained significant numbers of pink salmon originating from Alaskan rivers. Previous tagging information has indicated that even-year Alaskan pink salmon stocks are intercepted in the Queen Charlotte Islands fishery (Hollett 1970).

Stock and recruitment

Odd years. A stock and recruitment curve was derived for odd-numbered broodyears from the data in Table 3. The 1955, 1975, 1977, and 1979 broodyears were excluded from the analysis, owing to possible interceptions of Fraser River pink salmon in those years. The rate of return in those broodyears were considered to be unusually high and unlikely to be reliable. The stock and recruitment curve is illustrated in Fig. 20. The optimum escapement was estimated at 70 thousand fish and optimum rate of exploitation at 53%.

The yield curve based upon projected cumulative catch between 1960 and 2020 indicated that yield declines sharply at exploitation rates in excess of 60% (Fig. 21,22). Yield is similar for any sustained exploitation rate between 50-60%. The yield at an exploitation rate of 70% on an annual basis is about 50% of that which would be expected at a sustained exploitation rate of 50%.

The effects on catch and stock size were investigated if a policy of an annual 50% exploitation rate were adopted in 1961. The resulting recruitment from each escapement was the average of 100 simulations of equation 2. If a policy of 50% annual exploitation rate were adopted in 1961, a catch of 81 thousand pieces of Queen Charlotte Islands pink salmon and an escapement of 81 thousand fish could be expected in 1983 and 1985 (Table 5). Cumulative projected catches under a policy of 50% annual exploitation rate were compared with observed catches for the period 1961-1981. The results are similar up to 1975, after which the observed cumulative catch increases sharply (Fig. 23). This increase is coincident with the period of increased returns to the Fraser River pink salmon stock and suggests that most of the catch of odd-numbered years in the Queen Charlotte Islands fishery since 1977 has been derived from the Fraser River stock. Rehabilitation of the odd-year Queen Charlotte Islands pink salmon stock clearly involves reducing the level of exploitation.

Even years. A stock and recruitment curve for this stock was derived from its production data (Table 3) and is illustrated in Fig. 24. The optimum escapement was estimated at 928 thousand fish with an optimum exploitation rate of 50% (Table 4). The yield curve indicates that long-term yield is fairly constant at exploitation rates between 45-60% (Fig. 25). If a policy of 50% annual exploitation rate were adopted in 1960, a projected catch and escapement of 1.14 million pieces each would be available in 1984 (Table 5). If this policy had been adopted in 1960, observed and projected cumulative catches were about equal by 1980 (Fig. 26), so that there would have been little loss to the industry but escapements were projected to be 1.2 million fish, instead of the observed 630 thousand fish.

North Coast (Statistical Areas 3-5)

Catch and escapement

Catch of pink salmon in the North Coast fishery exceeded 2 million pieces annually in the even-numbered years between 1962-1972 (Fig. 27). In 1966 and 1977, the annual catch was approximately 4 million pieces. However, catch is greater in even-numbered years than in odd-numbered ones in this fishery. Significant numbers of Alaskan pink salmon are believed intercepted in even years because of the southerly approach of these stocks to the spawning grounds (Hollett 1970). Escapements during 1962-1972 in even-numbered years were usually in excess of 1.5 million fish, but subsequently declined (Fig. 27, Table 6).

Exploitation rates in this stock have usually varied between 50-70% annually (Fig. 28). The exploitation rate declined from in excess of 70% in 1966 to less than 35% in 1975, but increased subsequently to levels between 55-75% annually.

Gillnetters were the major gear in this fishery until 1970, after which the gillnet share of the catch declined, on average, to less than 50% of the total (Figs. 29,30). Trollers have made little impact on this fishery, accounting for less than 5% of the annual catch.

Stock recruitment

Odd years. A stock and recruitment curve was derived for the odd-numbered broodyears listed in Table 6. Escapements have ranged from 335 thousand to nearly 2.2 million, and thus allow for an investigation of stock dynamics under a large range of escapements (Fig. 31). Optimum escapements were estimated at 947 thousand fish with an optimum exploitation rate of 66% (Table 7).

Yield declines sharply at rates of exploitation in excess of 75% on a continuing basis (Figs. 32,33). Yield is similar for any exploitation rate on a sustained basis between 60 and 70%. If interceptions of other pink salmon stocks occur in this fishery, then productivity of this stock is lower than indicated, and the optimum rate of exploitation would be less than 66%. Exploitation rates of the odd-numbered broodyears have been generally less than 65% since 1960 (Fig. 28), but escapements have not increased (Fig. 27). If the stock and recruitment data is reliable, then the yield from this stock could be increased if escapements were lowered to 950 thousand. If escapement is set at this level, then the number of returning adults should be carefully monitored to ensure that the escapement is at optimum levels.

Even years. The stock and recruitment curve for the stock returning in even years is illustrated in Fig. 34. Again there was a wide range of escapements in this stock. This stock is apparently more productive than the one returning in odd-numbered years (Table 7). As this stock is apparently more productive than the odd-numbered one, the optimum exploitation rate is higher, at about 75% annually (Fig. 35, Table 7). Yield declines very rapidly at sustained exploitation rates in excess of 80% (Figs. 35,36).

Escapements for this stock are in excess of the suggested optimum of 900 thousand fish (Table 7), but any decision to decrease escapements in this stock should be followed up by a careful evaluation of the results. Productivity of the stock is overestimated if there are significant levels of interceptions in the fishery.

Central Coast (Statistical Areas 6-10)

Catch and escapement

Catch of pink salmon in the Central Coast fishery is cyclical, with catch higher in even-numbered years than in odd-numbered ones. However, catch in the odd-numbered years has been increasing since 1975, from 356 thousand pieces in that year to in excess of 4 million pieces in 1981 (Fig. 37). The escapement in 1962 was in excess of 7 million fish, but there have been no escapements of that magnitude since then.

The majority of the catch and escapement in the Central Coast is recorded in Statistical Areas 6-8, with the Atnarko River being a major contributor to both. Catches were larger than average in Statistical Areas 6-8 and 9-10 in 1962 and 1968, but proportionately more of the 1968 catch was taken in Rivers and Smith Inlets (Areas 9-10) than in 1962 (Figs. 38,39). The increase in catch in the odd-numbered years since 1975 was apparent only Statistical Areas 6-8. The pink salmon catch in Statistical Areas 9 and 10 is largely a by-catch of the sockeye salmon fishery, and pink salmon catches have not increased owing to restricted sockeye fisheries in the region (D. Peacock, pers. comm.).

Exploitation rate in the fishery was generally greater in even-numbered years than on odd-numbered ones (Fig. 40). Exploitation rate in the odd years has been increasing since 1969, especially in Statistical Areas 6-8 (Fig. 41). Exploitation rates in Rivers and Smith Inlets have been declining since 1969 (Fig. 42), so that the rate in 1980 was less than 20%, reflecting decreased effort in the sockeye salmon fishery.

The primary gear in the Central Coast fishery since 1960 has been the purse seine, with seiners generally accounting for in excess of 70% of the catch since 1970 (Figs. 43,44). The share of gillnetters has declined to less than 20% of the total. This trend is particularly striking in Areas 6-8 (Figs. 45,46), where seiners accounted for in excess of 85% of the catch during 1979-1981. The fishery in Rivers and Smith Inlets was primarily a gillnet fishery until 1966 (Figs. 47,48), but both trollers and seiners have accounted for significant portions of the catch until 1979. Areas 9 and 10 have been closed to seiners since 1979.

Stock and recruitment

Odd years. The stock and recruitment analysis was conducted for the odd-numbered broodyears of the Central Coast stock. Escapements have fluctuated from 300 thousand to 2.4 million fish (Table 8), but escapements have never attained the optimum level of 3.6 million (Fig. 49, Table 9). Optimum escapement levels for this stock could be tested by allowing escapements to increase. The optimum rate of exploitation was estimated at 43% (Table 9), a level that was generally exceeded in the fishery prior to 1969, and after 1969 except for 1971 and 1975 (Fig. 40).

The yield curve of cumulative catch versus exploitation rate based upon a 60-year projection from 1960 indicates that yield declines considerably at sustained exploitation rates in excess of 50% (Figs. 50,51). At 70% consistent annual exploitation rate, long term yield is only 20% of that derived from a sustained rate of 50% annual exploitation.

The effects on catch and stock size were investigated if a policy of an annual 45% exploitation rate were adopted in 1961. If this were the case, then under average conditions, a catch of in excess of 3.5 million pieces is projected for 1983 and 1985 (Table 10), while escapements are in excess of 4.3 million fish. Cumulative projected catches under a policy of an annual 45% exploitation rate were compared with cumulative observed catches in odd-numbered years between 1961 and 1981. Projected catches are about 15 million pieces greater than observed (Fig. 52). At this time, stock and recruitment analyses clearly suggests that increasing escapement for this stock will lead to significant increase in yield. The escapement in 1981 was less than 1.4 million fish, significantly below the apparent optimum escapement of 3.5 million fish.

Even years. Escapements have varied widely in this stock, with in excess of 7 million fish recorded in 1962 (Table 8). However, returns from that escapement were marginally over replacement levels (Fig. 53), with the evidence suggesting that optimum escapement levels are near 2.8 million fish (Table 9). The optimum exploitation rate was estimated at 69%.

The yield analysis indicates that long term catch declines considerably at sustained exploitation rates less than 60% and in excess of 80% (Fig. 54,55). However, the rate of decline is higher at exploitation rates in excess of 80% annually as compared with rates less than 60% annually. Annual exploitation rates for this stock have been near 70%, but escapements have not increased as they, on average, should have (Table 10). This suggests that productivity of this stock is overestimated, with the level of productivity markedly influenced by strong returns in the 1960s. If there were significant levels of interceptions during these fisheries (i.e. 1962), productivity of this stock could be overestimated. Escapements in this stock have not significantly increased under exploitation rates of 70% as is predicted by stock and recruitment analysis. A policy of 60% annual exploitation rate may allow escapements to increase to the optimum level.

Johnstone Strait and Georgia Strait (Statistical Areas 11-18,28)

Catch and escapement

Trends in catch and escapement were examined separately for the even- and odd-numbered years. Catch in the odd-numbered years in Johnstone and Georgia Strait is composed both of pink salmon from the Johnstone Strait-Georgia Strait stock and the Fraser River. Catches were allocated to the Johnstone Strait-Georgia Strait stock on the basis of timing curves generated by former tagging studies (Vernon et al. 1964, Hourston et al. 1965) and were made available by A. P. Gould (pers. comm.).

Catches from the odd-numbered year stock declined during 1963 to 1969 from about 2 million to just in excess of 100 thousand pieces (Fig. 56). They subsequently increased to in excess of 2 million pieces by 1979. Escapements showed the same trends in abundance as did the catches up to 1975. However, escapement declined in 1977 and 1979, but increased to in excess of 1.1 million pink salmon in 1981, due primarily to improved escapements in Statistical Areas 12 and 13. Exploitation rates for this stock have usually been in excess of 40% (Fig. 57). Exploitation rates were in excess of 70% in 1967, 1977, and 1979.

Catches from the even-numbered year stock have ranged from less than 500 thousand to nearly 4 million pieces (Fig. 58). Catches in excess of 3 million pieces were recorded in 1966, 1968, and 1976. Escapements have generally increased from a low of 230 thousand fish in 1960 to in excess of 1.1 million fish in 1980. Exploitation rates have usually been in excess of 50% in this stock and have averaged about 60% during 1952-1980 (Fig. 59).

The fishery for pink salmon in Johnstone Strait is largely conducted by purse seiners, and this gear usually accounted for in excess of 70% of the annual catch (Figs. 60,61). The troll portion of the catch has increased since 1952. The fishery in Statistical Areas 14-18 is also largely conducted by purse seiners (Fig. 62). In years when the net fisheries are restricted, trollers account for the majority of the catch (Fig. 63).

Stock and recruitment

Odd years. Escapements for this stock have ranged from less than 200 thousand to almost 1.8 million pink salmon (Table 11). The returns per spawning for the two largest spawning escapements in 1963 and 1975 was less than 1.0 (Fig. 64), which indicates that escapements were large enough to elicit density-dependent responses in egg and fry survival. Optimum escapement for this stock was estimated to be 561 thousand fish with an optimum exploitation rate of 72% (Table 12). However, catch and escapement both declined in this stock when exploitation rates were generally less than 70% (Figs. 56,57). An exploitation rate of 70% for this stock would seem to be excessive. As noted previously, catches for this stock are allocated on the basis of a 1959 tagging study, so it may be that productivity of the stock has been overestimated with the inclusion of some Fraser River pink salmon in the catch. Stock identification of the catches in the region would be valuable to compare with previous tagging studies.

Yield curves based upon the apparent productivity of the stock indicate a rapid decline in yield at sustained exploitation rates in excess of 80% annually (Figs. 65,66). However, these curves may not be indicative of actual productivity if Fraser River pink salmon are included in the catch.

Even years. Escapements for this stock have ranged from 230 thousand to 1.7 million fish (Table 11). Returns from these escapements have been quite variable (Fig. 67). Optimum escapement was estimated at approximately 850 thousand fish, and escapements from 1974-1980 were above this level (Fig. 58). Optimum exploitation rate was estimated at 65% (Table 12), somewhat greater than the level experienced, on average, in the fishery (Fig. 59). Escapements have generally increased during the same interval (Fig. 58), so an optimum exploitation rate of 65% would seem to be reasonably reliable.

The yield analyses indicates that catch declines sharply at sustained exploitation rates in excess of 75% (Figs. 68,69). A comparison of observed cumulative catch since 1960 and that projected under an exploitation rate of 65% annually are quite similar (Fig. 70). The exploitation history of this stock is such that it has usually been exploited near the optimum rate.

Juan de Fuca Strait (Statistical Areas 19-20)

Catches of pink salmon in this region are primarily of Fraser River origin, but some may be from rivers of the Georgia Strait region (Vernon et al. 1964, Hourston et al. 1965). The fishery is conducted almost entirely by purse seiners (Figs. 71,72). There are very small catches of pink salmon in even-numbered years.

West Coast of Vancouver Island (Statistical Areas 21-27)

Catch and escapement

The catch of pink salmon off the west coast of Vancouver Island has increased rapidly since 1965, but the increase has been in the odd-numbered years only (Fig. 73). Catches in 1979 and 1981 were 3.1 million and 2.8 million pieces, respectively. Catches were of a considerably lesser magnitude in the even-numbered years. The catch in 1970 was 293 thousand pieces, but the annual catch is usually less than 200 thousand pieces (Fig. 74). The escapement in 1972 was in excess of 450 thousand pink salmon, but escapements in 1978 and 1980 were about 100 thousand fish.

Exploitation rates in the even-year stock have been variable, but have been in excess of 50% for all even-numbered years during 1970-1980, except for 1972 (Fig. 72). Exploitation rates have been higher in the 1970s in this stock than in the 1950s or 1960s.

The fishery for pink salmon on the west coast of Vancouver Island is almost exclusively a troll fishery (Figs. 76-79). Catch of the even-numbered year stock is higher off the northwest coast of Vancouver Island (Fig. 76) than off the southwest one (Fig. 76). Escapements of pink salmon are also higher in the northwest section of Vancouver Island (Appendix 3). The catch in odd-numbered years is also higher off the northwest coast than off the southwest one.

Stock and recruitment

Escapements in the even-year stock have ranged from 34 thousand to 462 thousand pink salmon (Table 13). However, returns from this large escapement in 1972 were only about 50% of the escapement (Fig. 80). The optimum escapement was estimated at 160 thousand pink salmon with an optimum exploitation rate of 47% (Table 14). Exploitation rates in the 1970s were generally above this level, and escapements declined in this stock to below the level considered optimum.

The yield analyses indicates that catch declines rapidly at sustained exploitation rates in excess of 55% annually (Figs. 81,82). A comparison of observed cumulative catch between 1960 and 1980 and that projected under an exploitation rate of 50% annually indicates that, on average, projected catches would have equalled observed catches by 1974 and been in excess of observed catches by 1978 (Fig. 83). Exploitation rates below 50% for this stock would allow escapements to recover toward optimum levels.

Fraser River

Catch and escapement

Catch and escapement figures have been derived from the annual report of the International Pacific Salmon Fisheries Commission (Anon. 1981). Catch from the Fraser River pink salmon stock in IPSFC Convention Waters increased from less than 1 million pieces in 1965 to almost 8 million pieces in 1981 (Fig. 84). Escapements have also increased considerably since 1975 from less than 1.4 million pink salmon to in excess of 4.5 million salmon in 1981. Pink salmon are recolonizing upriver sections of the Fraser and Thompson Rivers.

Exploitation rates of the stock in Convention Waters has been in excess of 60% since 1971, but has ranged between 60-70% (Fig. 85). Escapements as well as catches have increased substantially under this level of exploitation.

The fishery in the Fraser River is conducted primarily by gillnetters (Fig. 86). Catches in the 1970s were usually in excess of 250 thousand pieces.

Stock and recruitment

Escapements of Fraser River pink salmon have varied between 1.1 and 3.6 million salmon during 1961-1979 (Table 15). Returns from the 1977 and 1979 escapements were in excess of 10 million salmon, so that escapements have not reached levels where density-dependent mortality factors could become significant (Fig. 87). The optimum escapement was estimated at nearly 5.1 million salmon and the optimum exploitation rate at 64% (Table 16). However, as new areas of the Fraser and Thompson Rivers are being recolonized due to the increase in abundance of the stock, the optimum level of escapement may be above the level of 5.1 million salmon as indicated in the analysis. Additional information is needed on productivity of escapements in excess of

5 million salmon for this stock.

The yield analysis indicated that catch was similar at sustained annual exploitation rates in the 50-70% range (Figs. 88,89). Fraser River pink salmon have been exploited near the optimum rate for Convention Area fisheries (Fig. 85). Exploitation of the stock in the 60-70% range has allowed escapements to increase, and this management strategy should continue.

DISCUSSION

If all pink salmon fisheries in British Columbia were conducted with stocks at optimum escapements, the maximum sustained annual yield is projected at 15.0 million pieces in the odd-numbered line and 11.5 million pieces in the even-numbered line. The maximum sustained yield from the Fraser River pink salmon stock is estimated at 9.0 million pieces, or about 60% of the total maximum sustained yield of all British Columbia odd-year pink salmon stocks. The yield of the Fraser River pink salmon stock may be underestimated, because optimum escapement may be higher than the 5.1 million salmon estimated by the stock and recruitment analysis. If increased escapements of Fraser River pink salmon continue to produce consistently good returns as they have for the 1975-1979 broodyears (Table 15), then maximum sustained yield will be in excess of 13 million pieces annually.

Average annual catches in British Columbia in the 1970s were generally at or above the levels indicated to be the maximum sustainable (Fig. 2). However, by 1981, escapements in most odd-year stocks were below the levels indicated to be optimum, but escapements in the even-year line were near optimum levels in most areas. The analysis has suggested that Fraser River pink salmon are intercepted in fisheries off the Queen Charlotte Islands, and it is known that they are intercepted in fisheries in Johnstone Strait and Georgia Strait (Vernon et al. 1964). Catches in the odd-year fisheries in the Queen Charlotte Islands have increased since 1975, coincident with the period of increasing returns to the Fraser River stock and Central Coast stock. As outlined by Wong (1982), it is currently assumed that there are no significant interceptions of Fraser River pink salmon in fisheries north of Johnstone Strait. However, rates of return from the odd-year Queen Charlotte Islands stock for the 1977 and 1979 broodyears are too high to assume that all of the pink salmon caught in the Queen Charlotte Islands fishery are from the Queen Charlotte Islands stock. Escapement of the odd-year line in the North Coast has not increased at the rate that could account for increased catches in the Queen Charlotte Islands fishery. Interception fisheries in Statistical Areas 1 and 2W have accelerated since 1974 (L. Orman, pers. comm.) and stock composition is uncertain, but catches could contain pink salmon of Alaskan, Skeena/Nass, Central Coast, and Fraser River origin.

Escapements to the odd-year line of pink salmon in Johnstone Strait and Georgia Strait south of Knight Inlet (Statistical Area 12) have declined dramatically since the mid 1950s (Appendix 3). Pink salmon from this stock are mixed with those of the Fraser River and are harvested in fisheries in

Johnstone Strait, off the west coast of Vancouver Island, and in the Strait of Juan de Fuca. Pink salmon of the Johnstone Strait-Georgia Strait stock migrate primarily through Johnstone Strait (Vernon et al. 1964). The decline in escapements of pink salmon bound for rivers south of Knight Inlet and north of the Fraser River is probably due to lower productivity of this stock as compared with the Fraser River stock coupled with extensive fisheries in Johnstone Strait. Rehabilition of the Johnstone Strait-Georgia Strait odd-year line of pink salmon requires reducing exploitation on the stock in Johnstone Strait. Methods to distinguish between pink salmon of this stock and those of the Fraser River would be an aid in management of the stocks in Johnstone Strait. Current management decisions in the Johnston Strait fishery are based upon the results of the 1959 tagging study (Vernon et al. 1964).

On a coastwide basis, catch and escapement of pink salmon in British Columbia have shown no unidirectional trend during 1951-1981. However, some stocks are overexploited, particularly those in odd-numbered years. There may be errors in assigning catches to specific stocks, so that productivities of the different stocks examined in this report may be in error. It is necessary to develop methods of stock identification to correctly allocate catch to specific stocks.

The coastwide share of the pink salmon catch of the purse seine fleet has usually been approximately 60% of the total annual catch (Table 5). The troll fleet has accounted for an increasing portion of the catch since 1955, while that of the gillnet sector has declined. The troll fleet accounted for a larger portion of the catch than did the gillnet fleet during 1979-1981. Shifting of the fisheries from terminal areas to areas where stocks are more mixed and also competition among different sectors of the commercial fleet account for the declining proportion of the total catch of the gillnet fleet.

Pink salmon stocks in northern and central British Columbia are more productive in even-year broodyears than in odd-year ones when comparing even- and odd-year stocks in the same area. However, interceptions of Alaskan pink salmon in even years (Hollett 1970) may account for some of this higher productivity. In southern British Columbia, odd-years stocks are more productive than even-year ones (i.e. Johnstone Strait and Georgia Strait). Even-year stocks thus appear to be better adapted to northern environmental conditions whereas odd-year stocks are better adapted to southern environmental conditions. This may be related to the broodyear occupying different refugia during the last glaciation (Aspinwall 1974). Further research on differences in population biology of the even- and odd-year lines might account for differences in productivity of the lines.

ACKNOWLEDGMENTS

Mr. Fred Wong made accessible the data bases upon which the catch and escapement analysis was based. Mr. Bruce Bernard designed the computer software for the graphics in this report, as well as many of the computer programs used in the stock and recruitment analysis and projections. Mr. Bernard's assistance in this project was invaluable, and the study could not have been conducted in its present form without his computer programming and computer graphics ability. Significant suggestions for improvements to the manuscript were made by J. Woody (International Pacific Salmon Fisheries Commission) and D. Peacock, L. Orman, and R. Kadowaki (North Coast Division, Field Services).

REFERENCES

Anonymous. 1981. Annual Report. International Pacific Salmon Fisheries Commission, New Westminster, B.C. 46 p.

Aspinwall, N. 1974. Genetic analysis of North American populations of the pink salmon, Oncorhynchus gorbuscha, possible evidence for the neutral mutation - random drift hypothesis. Evolution 28: 295-305.

Healey, M. C. 1982. Catch, escapement, and stock-recruitment for British Columbia chinook salmon since 1951. Can. Tech. Rep. Fish. Aquat. Sci. 1107: 77 p.

Hoar, W. S. 1951. The chum and pink salmon fisheries of British Columbia, 1917-1947. Bull. Fish. Res. Board Can. 90: 1-46.

Hollett, E. L. 1970. Summary of salmon tagging in Dixon Entrance and Hecate Strait in 1968. Fish. Serv. Pac. Reg. Tech. Rep. 1970-13. 26 p.

Hourston, A. S., E. H. Vernon, and G. A. Holland. 1965. The migration, composition, exploitation, and abundance of odd-year pink salmon runs in and adjacent to the Fraser River Convention Area. Int. Pac. Salmon Fish. Comm. Bull. No. 17: 151 p.

Kwain, W. 1982. Spawning behavior and early life history of pink salmon (Oncorhynchus gorbuscha) in the Great Lakes. Can. J. Fish. Aquat. Sci. 39: 1353-1360.

Ricker, W. E. 1962. Regulation of the abundance of pink salmon populations. pp. 155-201. In H. R. MacMillan Lectures in Fisheries, Symposium on Pink Salmon. University of British Columbia.

Takagi, K., K. V. Aro, A. C. Hartt, and M. B. Dell. 1981. Distribution and origin of pink salmon (Oncorhynchus gorbuscha) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. No. 40: 195 p.

Vernon, E. H., A. S. Hourston, and G. A. Holland. 1964. The migration and exploitation of pink salmon runs in and adjacent to the Fraser River Convention Area in 1959. Int. Pac. Salmon Fish. Comm. Bull. No. 15: 296 p.

Wong, F. Y. C. 1982. Analyses of stock-recruitment dynamics of British Columbia salmon. M. Sc. thesis, University of British Columbia, Vancouver, B.C. 221 p.

1983. Historical salmon commercial catch data system of the Fisheries Research Branch, Department of Fisheries and Oceans, Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. No. 1156: 94 p.

Table 1. Commercial catch (pieces) of pink salmon in British Columbia, 1951-1981.

Year	Gillnet	Seine	Troll	Total
1951	2537700	6353810	103920	8995430
1952	2991280	4021570	23770	7036620
1953	2428460	8018090	172540	10619090
1954	1706490	1782140	17370	3506000
1955	3505960	6471650	141750	10119360
1956	1883070	5416470	52310	7351850
1957	4603960	6319190	386950	11310100
1958	2610800	4093150	204220	6908170
1959	2209520	3757730	809140	6776390
1960	1536980	2451580	108970	4097530
1961	2926010	4880760	498180	8304950
1962	7091510	15765950	571160	23428620
1963	3597920	7508720	1094800	12201440
1964	328060	5841240	504080	9628380
1965	1575930	3255010	278310	5109250
1966	5512910	10945120	803320	17261350
1967	2023360	5406300	2229020	9658680
1968	2398370	16201400	1565510	20165280
1969	997190	888970	683050	2569210
1970	4246360	8058550	1212070	13516980
1971	2133780	5037830	1284370	8455980
1972	1657710	11518800	1033300	14209810
1973	1289610	3999930	1231790	6521330
1974	1525150	5239070	609720	7373940
1975	1035760	2790020	807820	4633600
1976	1610290	7933120	805440	10348850
1977	2278110	5405830	2672420	10356360
1978	1382890	8939000	426110	10748000
1979	1017610	6770440	4034460	11822510
1980	1257740	7143870	1421360	9822970
1981	2160130	11485720	4439930	18085780

Table 2. Effort (days fished) and catch per day of pink salmon for commercial vessels in British Columbia, 1963-1981.

	Gillnet		Seine		Troll	
Year	Effort	C.P.U.E.	Effort	C.P.U.E.	Effort	C.P.U.E.
1963	109991	28.2	11673	611.3	122636	8.5
1964	124524	20.9	10756	423.6	137625	3.3
1965	95137	11.9	9750	275.2	132232	2.0
1966	106055	39.2	10922	829.4	138253	4.9
1967	121821	16.6	12240	441.5	137683	16.1
1968	133398	17.5	14440	1073.9	14475	10.7
1969	97539	10.1	8899	99.3	130321	5.2
1970	126441	32.9	15029	492.0	137981	8.5
1971	103644	20.5	10840	456.7	149169	8.5
1972	107921	15.2	14660	772.5	136619	7.6
1973	108114	11.8	16789	237.7	128862	9.3
1974	88230	17.3	13094	400.1	122851	5.0
1975	60363	17.2	10570	264.0	118387	6.7
1976	77651	20.7	14021	565.8	130392	6.1
1977	83802	27.2	16528	327.1	151588	17.3
1978	68930	20.1	13287	672.8	148924	2.9
1979	50551	19.8	12141	557.7	162327	24.9
1980	50739	19.0	12161	498.3	193301	6.9
1981	52173	41.1	10286	1116.6	164079	27.1

Table 3. Escapements and returns for 1954-1979 broodyears for Queen Charlotte Islands (Statistical Areas 1-2) pink salmon. Estimates are listed to the nearest thousand.

Broodyear	Escapement	Return	R/S
	Odd Years[1]		
1955	24	224	9.33
1957	66	83	1.26
1959	52	115	2.21
1961	70	217	3.10
1963	139	195	1.40
1965	115	205	1.78
1967	78	202	2.59
1969	127	135	1.06
1971	33	96	2.91
1973	38	113	2.97
1975	25	187	7.48
1977	14	502	35.86
1979	40	717	17.93
	Even years		
1954	1092	1226	1.12
1956	823	1935	2.35
1958	726	1030	1.42
1960	617	1956	3.17
1962	883	992	1.12
1964	645	3466	5.37
1966	1803	3537	1.96
1968	2254	2387	1.06
1970	1539	2769	1.80
1972	1408	1331	0.95
1974	772	2630	3.41
1976	983	1468	1.49
1978	904	1641	1.82

[1] Broodyears 1955, 1975, 1977, and 1979 were not used for stock and recruitment analysis.

Table 4. Parameters for stock and recruitment curves for Queen Charlotte Islands pink salmon. Returns and spawners are listed in Table 3. Yield and spawners are listed to nearest thousand.

Parameter	Broodyear	
	Odd	Even
a	1.29	1.19
B	172	2230
maximum sustained yield	79	928
optimum escapement	70	928
optimum exploitation rate	53%	50%

Table 5. Projected returns, catches, and escapements by managing Queen Charlotte Islands pink salmon for an annual exploitation rate of 50% for all broodyears. Observed returns for 1960 and 1961 are used in the projections. Estimates are listed to the nearest thousand.

Year	Returns	Catch	Escapement
Odd Years			
1961	115	57	57
1963	140	70	70
1965	161	80	80
1967	162	81	81
1969	172	86	86
1971	169	84	84
1973	162	81	81
1975	170	85	85
1977	167	83	83
1979	169	84	84
1981	169	84	84
1983	162	81	81
1985	163	81	81
1987	162	81	81
Even Years			
1960	1030	515	515
1962	1471	735	735
1964	1800	900	900
1966	1993	996	996
1968	2287	1143	1143
1970	2155	1077	1077
1972	2327	1163	1163
1974	2340	1170	1170
1976	2342	1171	1171
1978	2395	1197	1197
1980	2371	1185	1185
1982	2191	1095	1095
1984	2274	1137	1137
1986	2081	1040	1040

Table 6. Escapements and returns for 1948-1979 broodyears for North Coast (Statistical Areas 3-5) pink salmon. Estimates are listed to the nearest thousand.

Broodyear	Escapement	Return	R/S
	Odd Years		
1949	638	2888	4.53
1951	631	1006	1.59
1953	335	2313	6.90
1955	522	4301	8.24
1957	1132	2967	2.62
1959	1766	4369	2.47
1961	2046	2773	1.36
1963	1368	2872	2.10
1965	1686	1623	0.96
1967	681	1639	2.41
1969	929	2669	2.87
1971	1373	2353	1.71
1973	1388	3213	2.31
1975	2177	5183	2.38
1977	1317	1590	1.21
1979	604	3352	5.55
	Even years		
1950	804	3541	4.40
1952	1799	1733	0.96
1954	431	2482	5.76
1956	489	2937	6.01
1958	874	1190	1.36
1960	486	4980	10.24
1962	1668	5105	3.06
1964	2128	5862	2.75
1966	1413	4802	3.40
1968	2206	3992	1.81
1970	1313	5107	3.89
1972	2267	1329	0.59
1974	761	2065	2.71
1976	1171	4823	4.12
1978	1394	2747	1.97

Table 7. Parameters for stock and recruitment curves for North Coast pink salmon. Returns and spawners are listed in Table 6. Yield and spawners are listed to nearest thousand.

	Broodyear	
Parameter	Odd	Even
a	1.72	2.09
B	2496	2527
maximum sustained yield	1838	2542
optimum escapement	947	893
optimum exploitation rate	66%	74%

Table 8. Escapements and returns for 1949-1979 broodyears for Central Coast (Statistical Areas 6-10) pink salmon. Estimates are listed to the nearest thousand.

Broodyear	Escapement	Return	R/S
	Odd Years		
1949	1331	4003	3.01
1951	1407	1663	1.18
1953	663	1823	2.75
1955	704	1905	2.71
1957	1027	1683	1.64
1959	973	5833	5.99
1961	2265	6400	2.83
1963	2392	3402	1.42
1965	879	740	0.84
1967	311	523	1.68
1969	393	1618	4.12
1971	1019	1529	1.50
1973	551	964	1.75
1975	613	1968	3.21
1977	852	3519	4.13
1979	1429	5476	3.83
	Even years		
1950	695	3554	5.11
1952	967	2635	2.72
1954	831	5242	6.31
1956	1348	3006	2.23
1958	777	4859	6.25
1960	2233	25202	11.29
1962	7018	7962	1.13
1964	2540	10089	3.97
1966	2728	15407	5.65
1968	3840	8368	2.18
1970	1910	11900	6.23
1972	2968	6697	2.26
1974	2186	6443	2.95
1976	2800	8849	3.16
1978	3560	6190	1.74

Table 9. Parameters for stock and recruitment curves for Central Coast pink salmon. Returns and spawners are listed in Table 8. Yield and spawners are listed to nearest thousand.

Parameter	Broodyear	
	Odd	Even
a	0.98	1.85
B	8143	7639
maximum sustained yield	2652	6295
optimum escapement	3515	2828
optimum exploitation rate	43%	69%

Table 10. Projected returns, catches, and escapements by managing Central Coast pink salmon for an annual exploitation rate of 45% on odd-numbered broodyears and 70% on even-numbered ones. Observed returns for 1960 and 1961 are used in the projections. Estimates are listed to the nearest thousand.

Year	Returns	Catch	Escapement
		Odd Years	
1961	5833	2625	3208
1963	7496	3373	4123
1965	7019	3158	3860
1967	7568	3405	4162
1969	7531	3389	4142
1971	7194	3237	3957
1973	7452	3353	4098
1975	7661	3447	4213
1977	8025	3611	4413
1979	8016	3607	4408
1981	8236	3706	4530
1983	8141	3663	4478
1985	7881	3546	4334
1987	8294	3732	4561
		Even Years	
1960	4858	3401	1457
1962	7438	5206	2231
1964	9349	6544	2804
1966	10293	7205	3088
1968	9641	6749	2892
1970	10673	7471	3202
1972	10478	7334	3143
1974	10853	7597	3255
1976	11195	7836	3358
1978	10973	7681	3292
1980	10719	7503	3215
1982	9650	6755	2895
1984	9951	6966	2985
1986	10661	7463	3198

Table 11. Escapements and returns for 1950-1978 broodyears for Johnstone Strait and Georgia Strait (Statistical Areas 11-18) pink salmon. Estimates are listed to the nearest thousand.

Broodyear	Escapement	Return	R/S
	Odd Years		
1957	1164	2292	1.97
1959	783	2867	3.66
1961	1048	3751	3.58
1963	1759	1016	0.58
1965	590	924	1.57
1967	177	337	1.90
1969	218	2094	9.61
1971	1430	2195	1.53
1973	1175	2256	1.92
1975	1566	895	0.57
1977	261	2346	8.99
	Even years		
1950	634	3738	5.90
1952	1032	975	0.94
1954	575	1511	2.63
1956	590	2137	3.62
1958	770	574	0.75
1960	230	1454	6.32
1962	702	1476	2.10
1964	622	4778	7.68
1966	1338	5217	3.90
1968	1512	3494	2.31
1970	1152	1449	1.26
1972	715	2676	3.74
1974	1124	5486	4.88
1976	1700	2301	1.35
1978	1016	2236	2.20

Table 12. Parameters for stock and recruitment curves for Johnstone Strait and Georgia Strait pink salmon. Returns and spawners are listed in Table 11. Yield and spawners are listed to nearest thousand.

Parameter	Broodyear	
	Odd	Even
a	1.98	1.68
B	1551	2206
maximum sustained yield	1443	1567
optimum escapement	561	844
optimum exploitation rate	72%	65%

Table 13. Escapements and returns for 1954-1978 broodyears for West Coast Vancouver Island (Statistical Areas 21-27) pink salmon. Estimates are listed to the nearest thousand. Pink salmon are present only in even-numbered years.

Broodyear	Escapement	Return	R/S
1954	136	264	1.94
1956	71	96	1.35
1958	67	39	0.58
1960	34	227	6.68
1962	122	113	0.93
1964	95	548	5.77
1966	395	524	1.33
1968	320	489	1.53
1970	196	521	2.66
1972	462	236	0.51
1974	100	410	4.10
1976	175	209	1.19
1978	101	317	3.14

Table 14. Parameters for stock and recruitment curves for West Coast Vancouver Island pink salmon. Returns and spawners are listed in Table 13. Yield and spawners are listed to nearest thousand.

Parameter	Even years
a	1.11
B	377
maximum sustained yield	141
optimum escapement	159
optimum exploitation rate	47%

Table 15. Escapements and returns for 1961-1979 broodyears for Fraser River pink salmon. Estimates are listed to the nearest thousand. Pink salmon are present only in odd-numbered years.

Broodyear	Escapement	Return	R/S
1961	1094	5326	4.87
1963	1953	2271	1.16
1965	1191	12850	10.79
1967	1831	3849	2.10
1969	1529	9707	6.35
1971	1804	6753	3.74
1973	1754	4867	2.77
1975	1367	8173	5.98
1977	2388	14100	5.90
1979	3561	18400	5.17

Table 16. Parameters for stock and recruitment curves for Fraser River pink salmon. Returns and spawners are listed in Table 15. Yield and spawners are listed to nearest thousand.

Parameter	Odd years
a	1.65
B	13239
maximum sustained yield	9015
optimum escapement	5071
optimum exploitation rate	64%

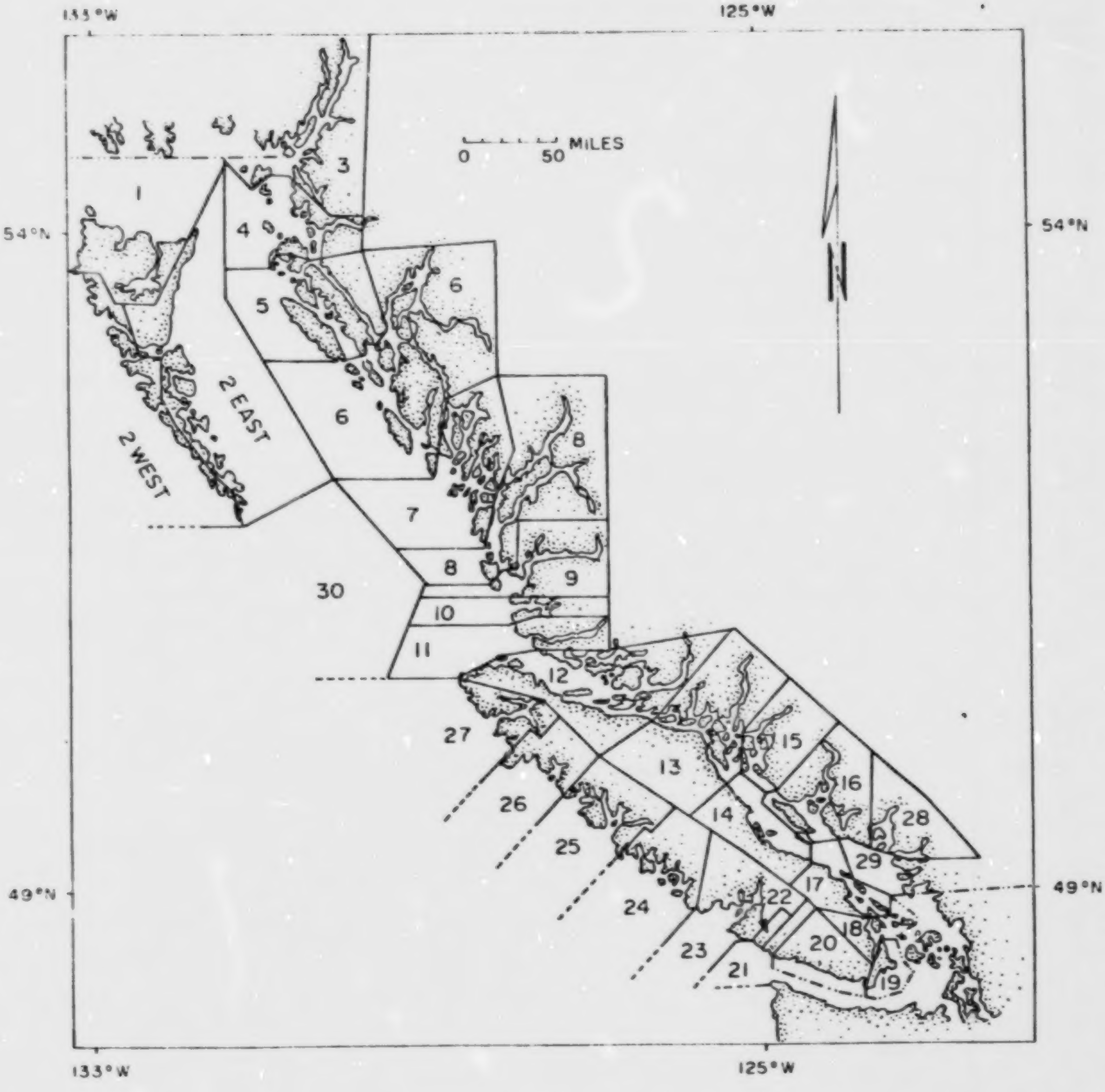
133°W
125°W
54°N
49°N
0
50
MILES
N
1
2 EAST
2 WEST
3
4
5
6
6
7
8
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. 1. Fishery statistical areas in British Columbia.

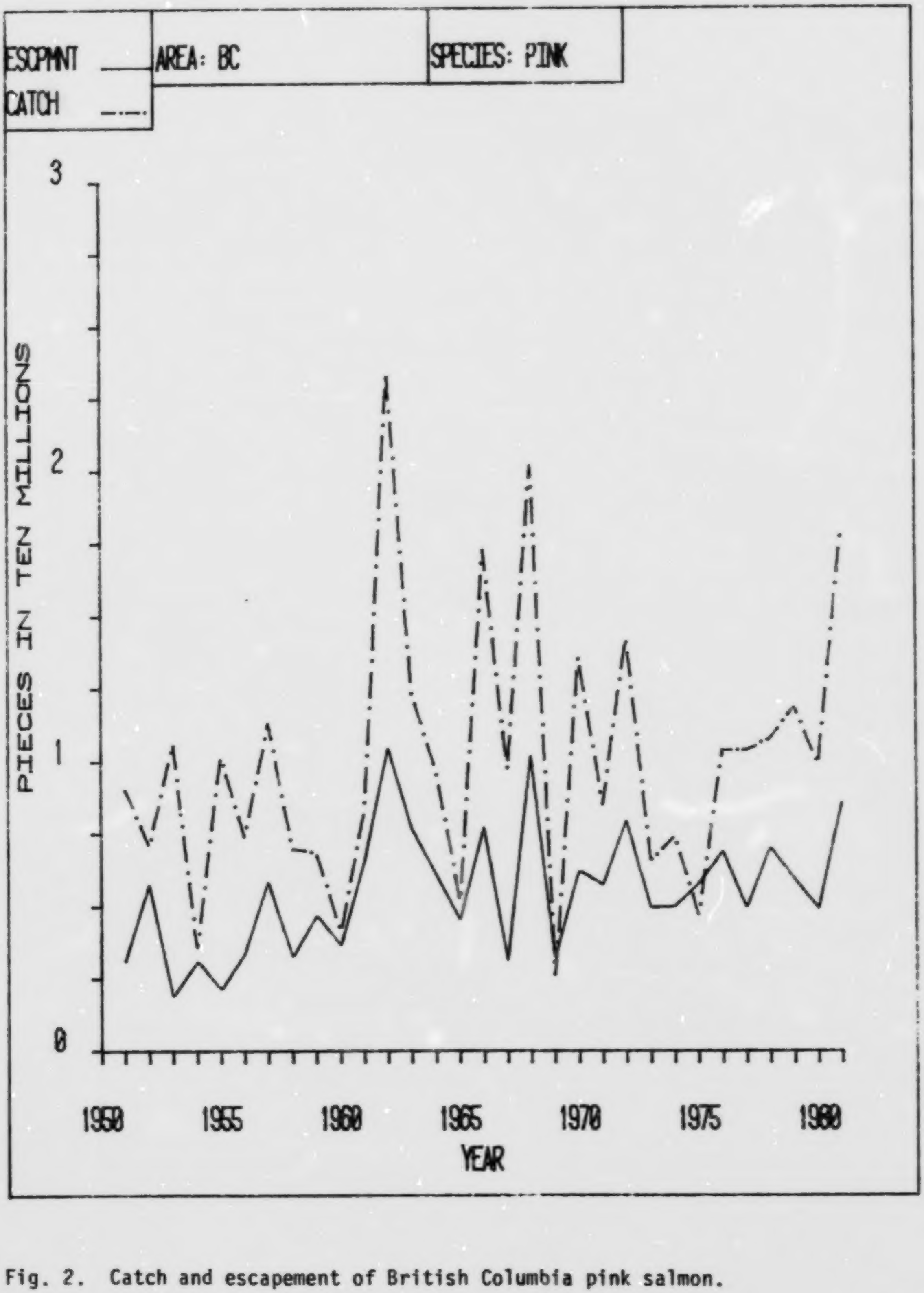

Fig. 2. Catch and escapement of British Columbia pink salmon.

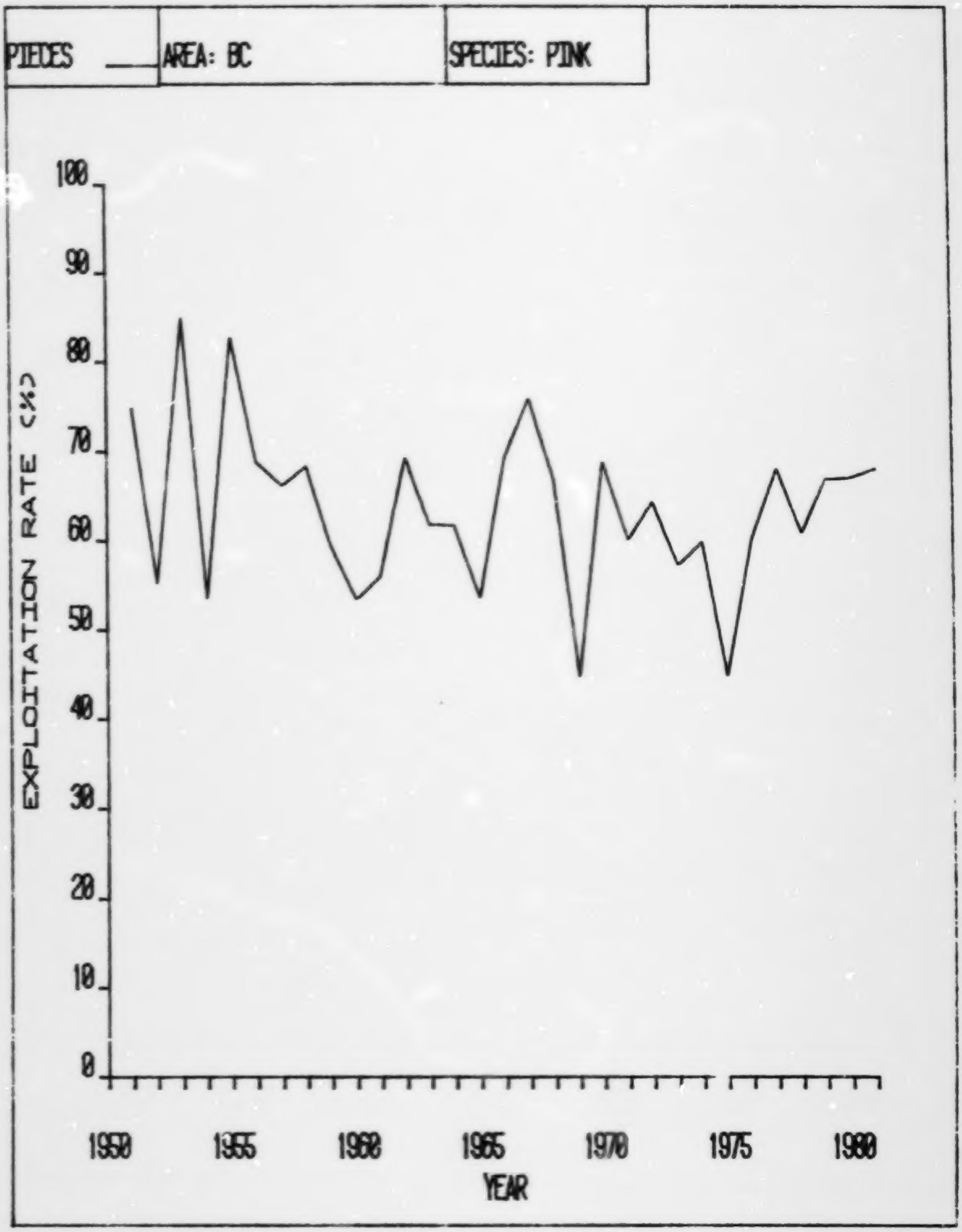

Fig. 3. Exploitation rate of British Columbia pink salmon.

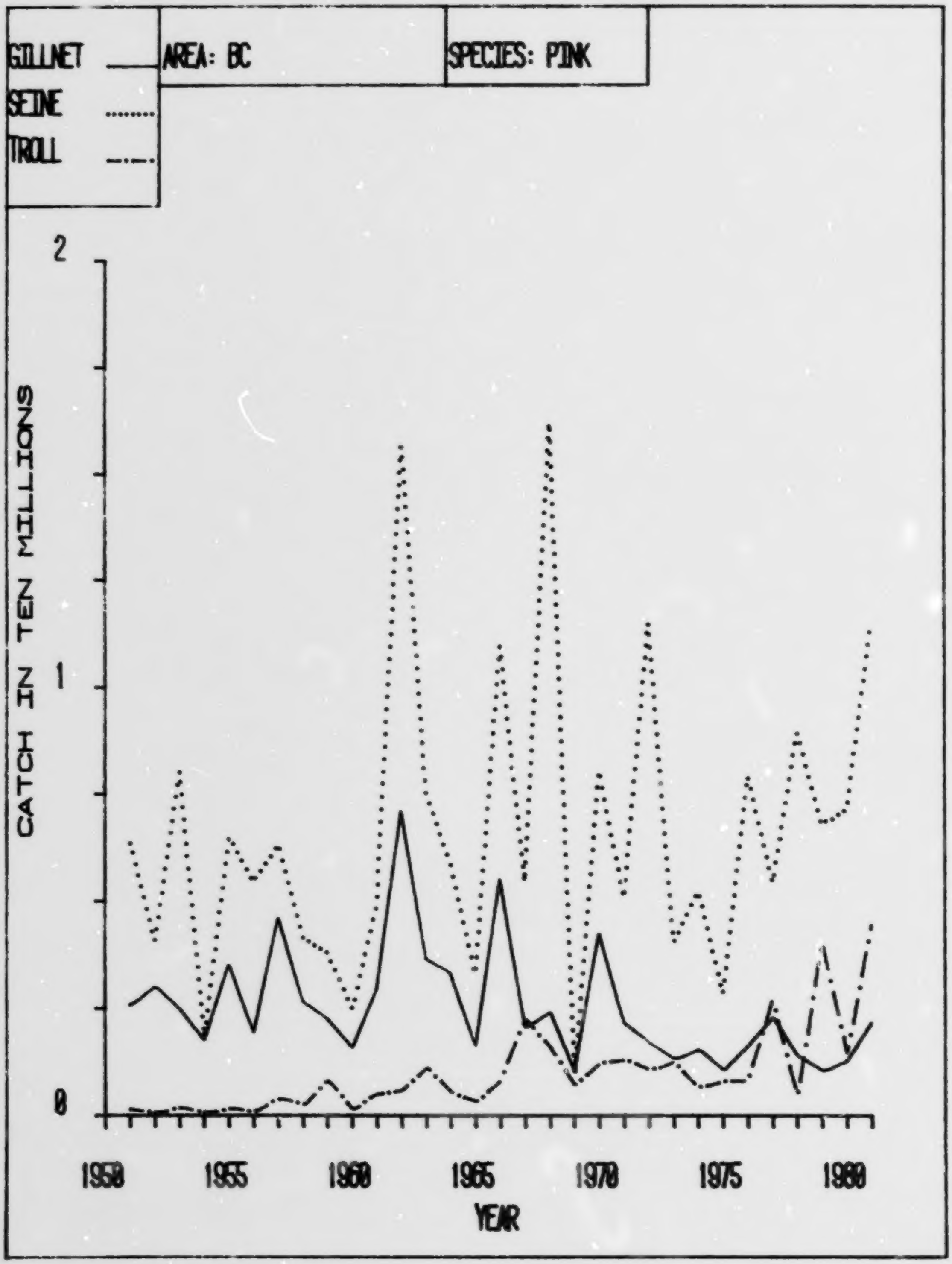

Fig. 4. Catch by gear of British Columbia pink salmon.

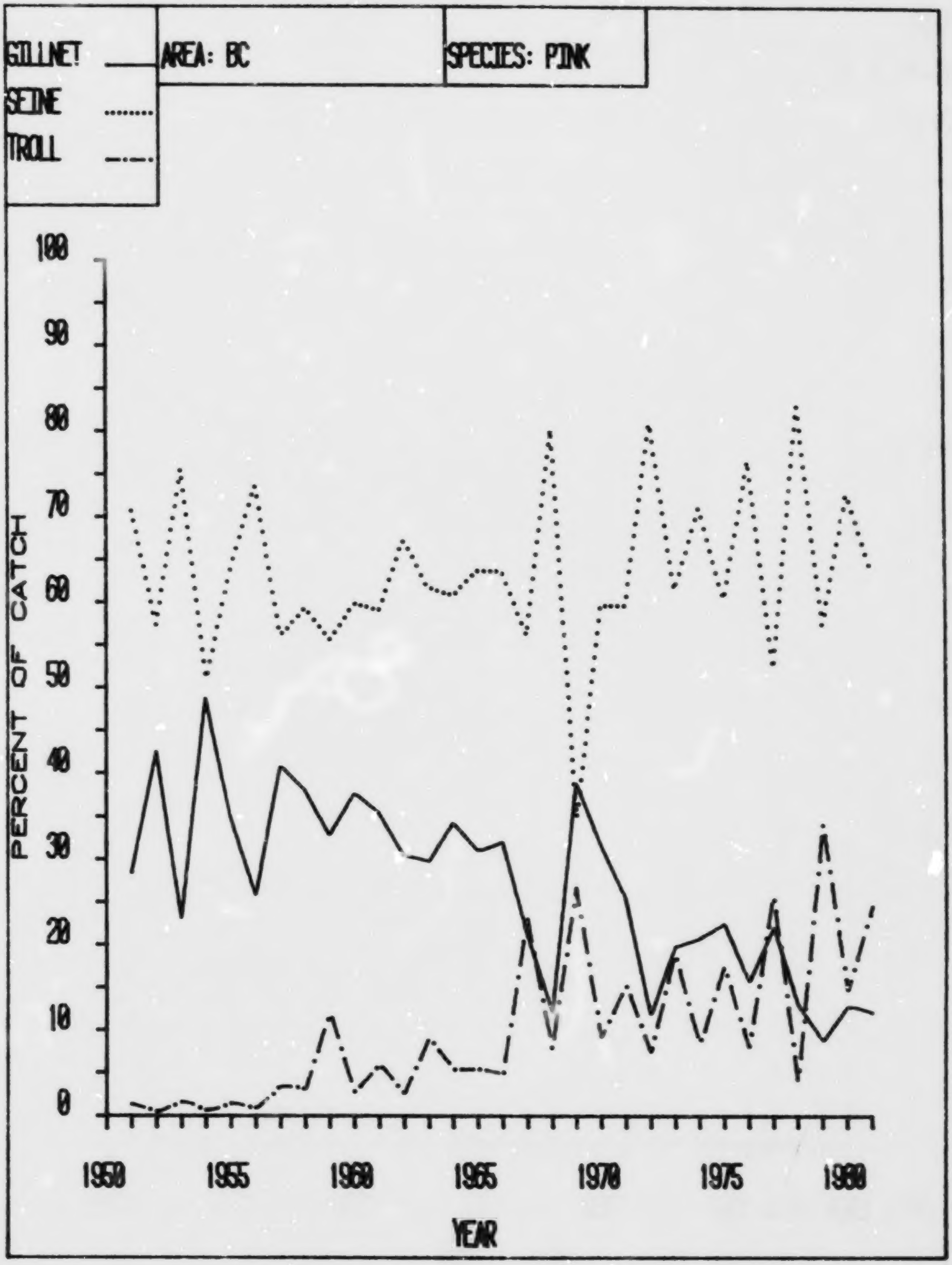

Fig. 5. Percent of total catch by gear of British Columbia pink salmon.

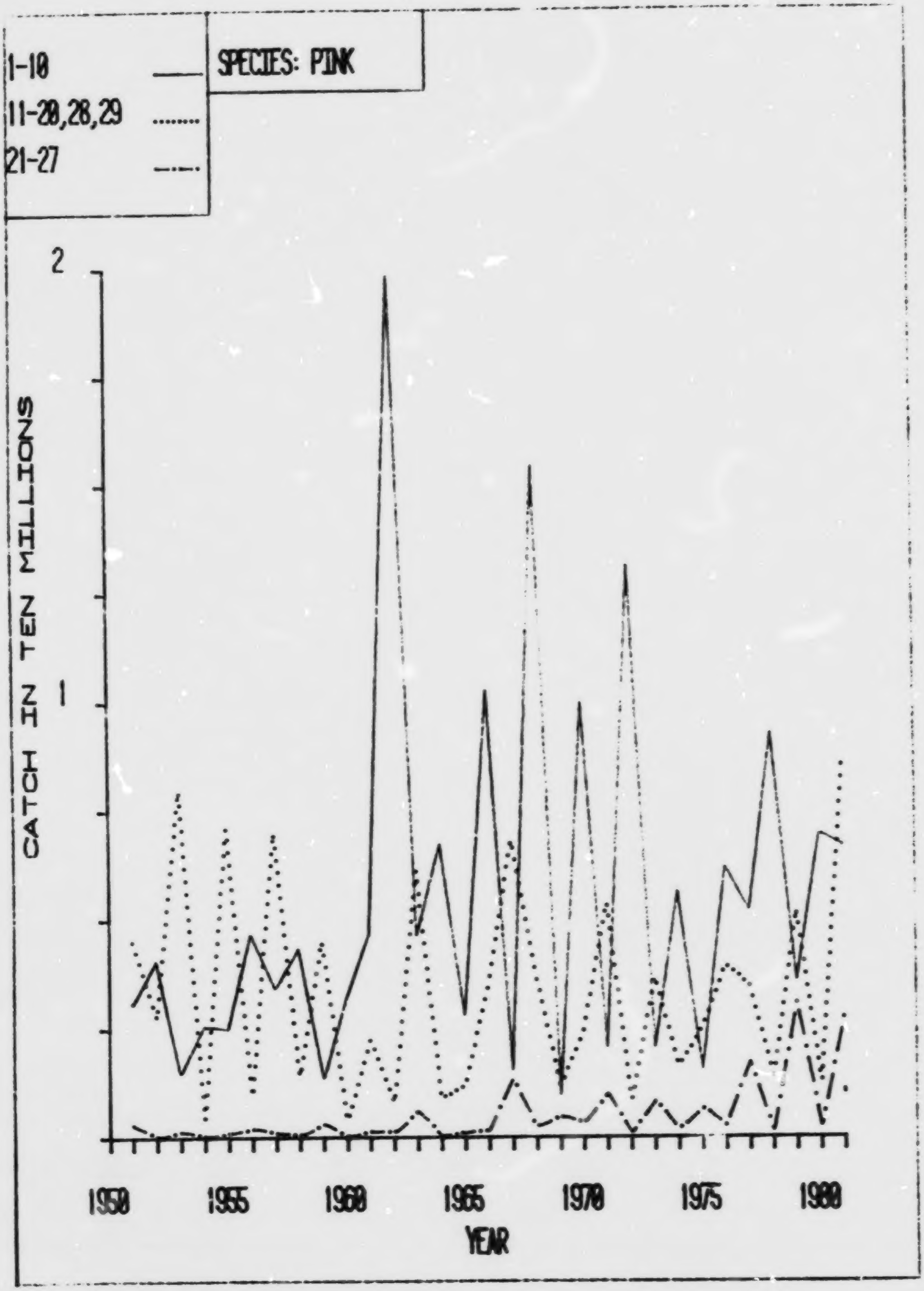

Fig. 6. Catch in northern, southern, and west coast of Vancouver Island regions of pink salmon.

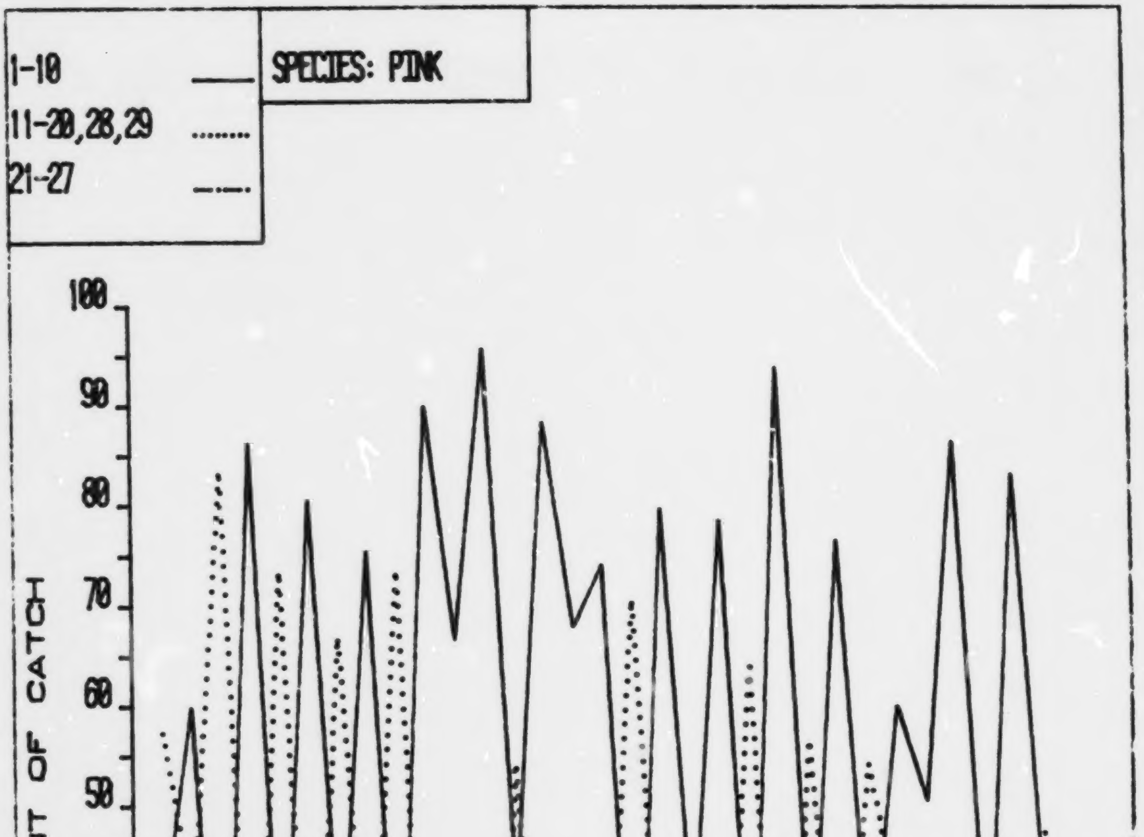

Fig. 7. Percent of total British Columbia catch by major fishery region.

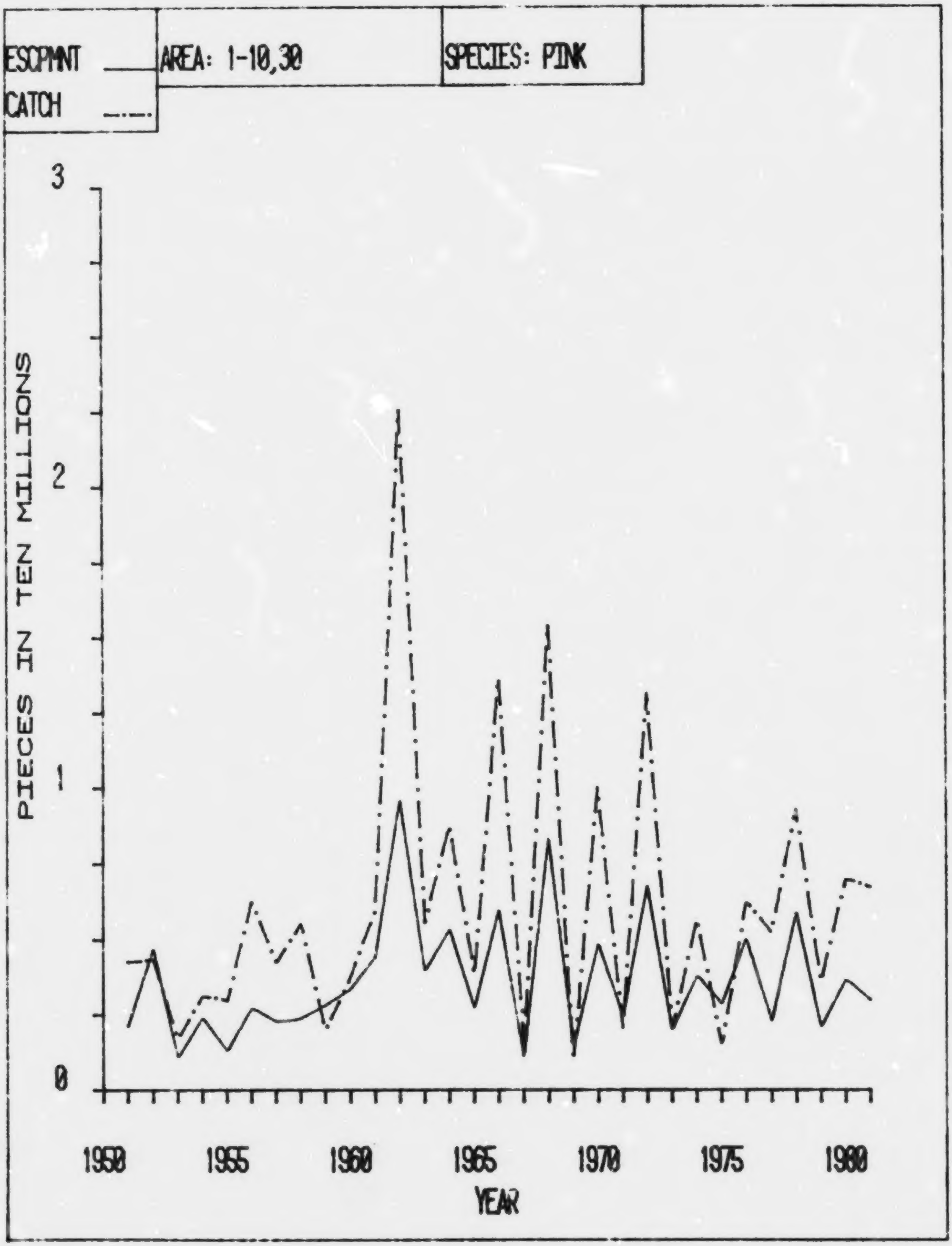

Fig. 8. Catch and escapement of North and Central Coast pink salmon.

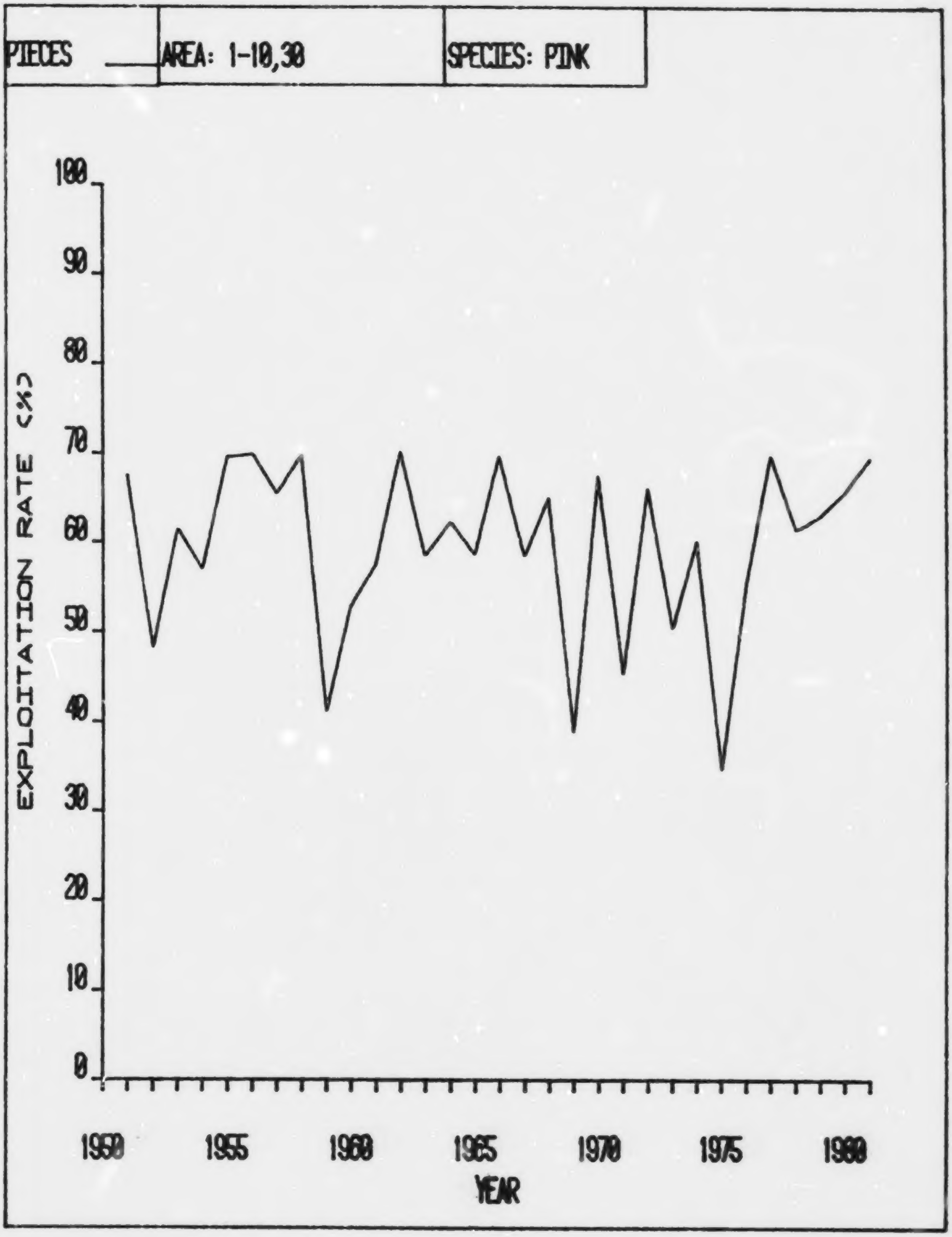

Fig. 9. Exploitation rate of North and Central Coast pink salmon.

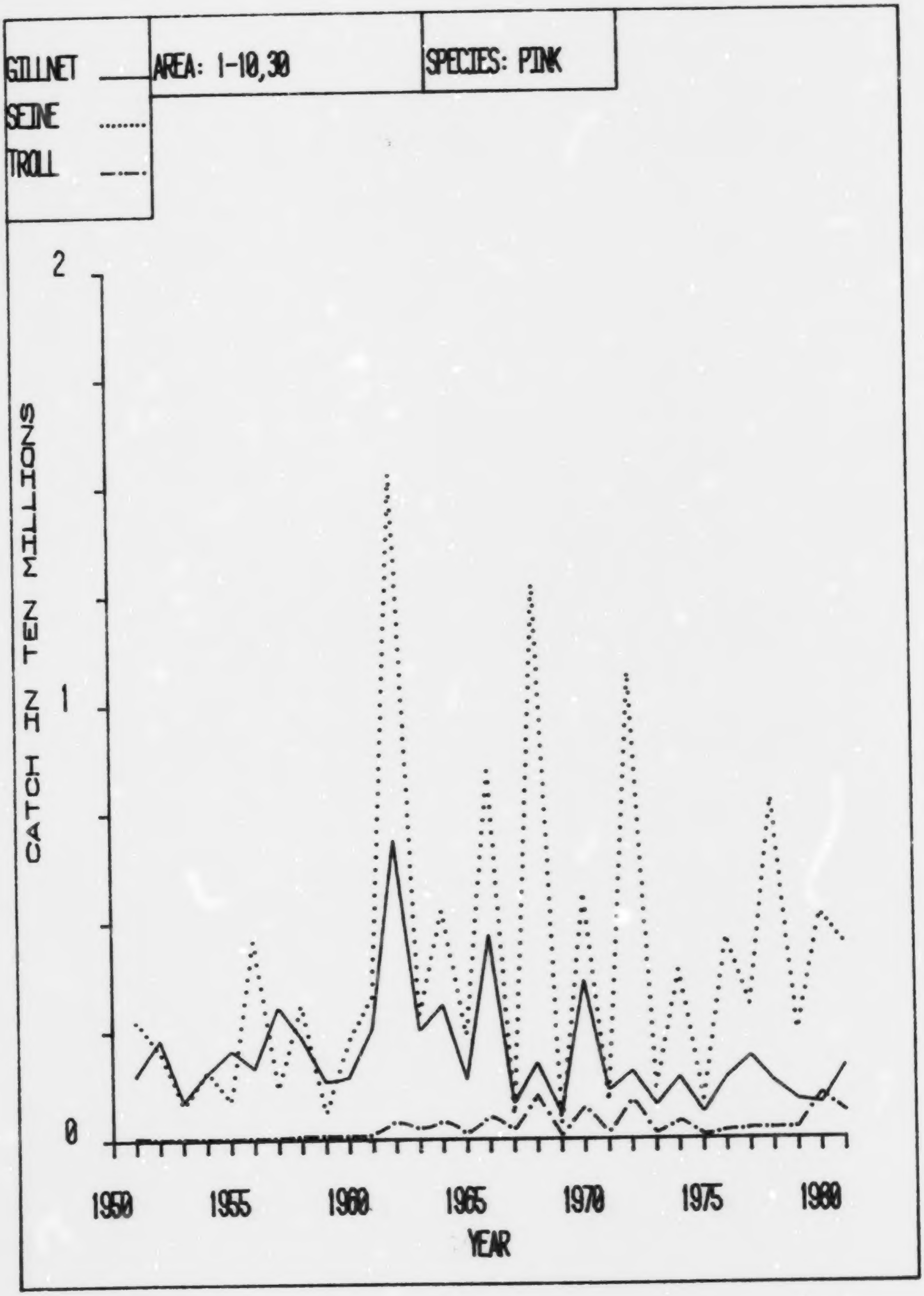

Fig. 10. Catch by gear of North and Central Coast pink salmon.

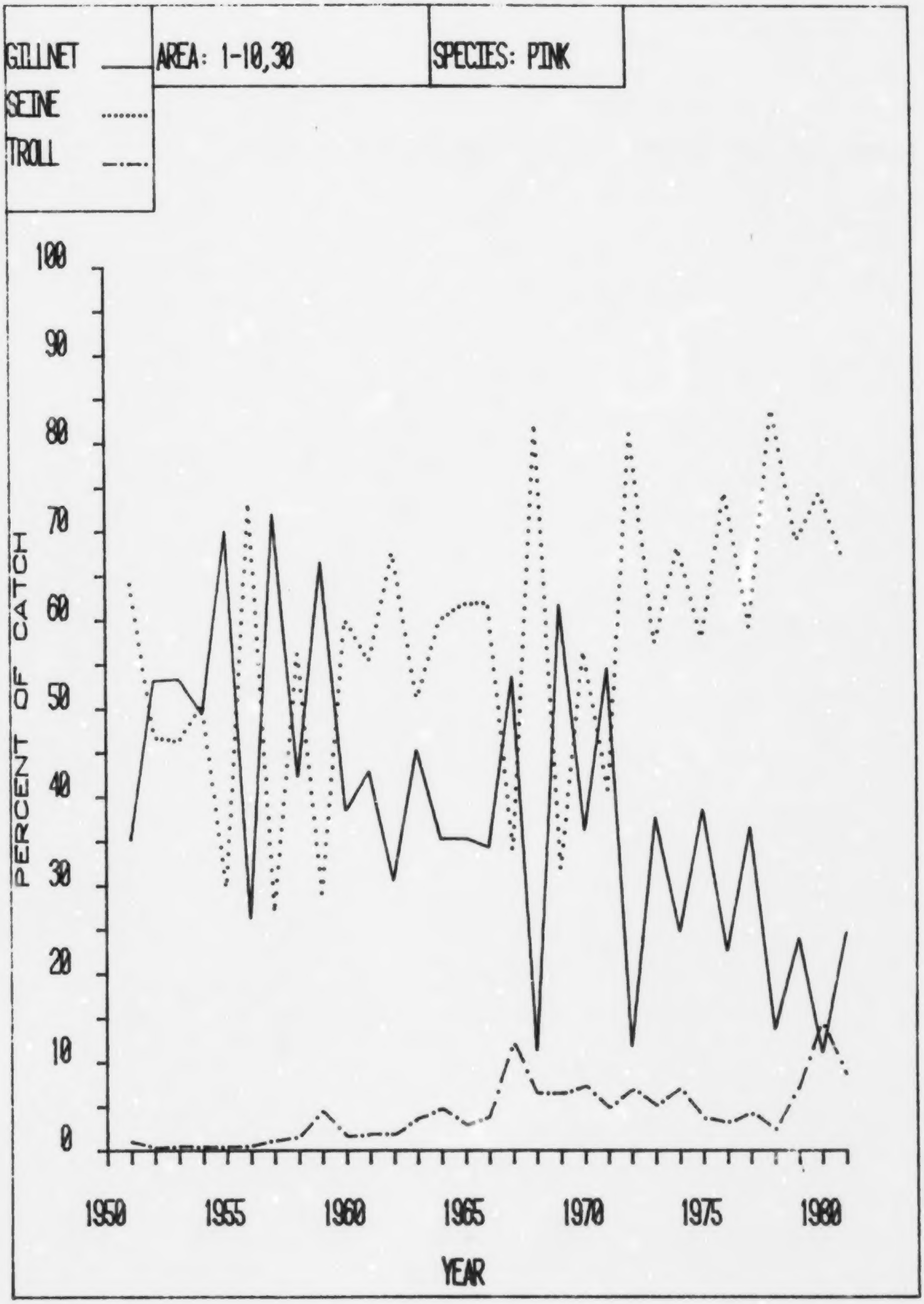

Fig. 11. Percent of total catch by gear of North and Central Coast pink salmon.

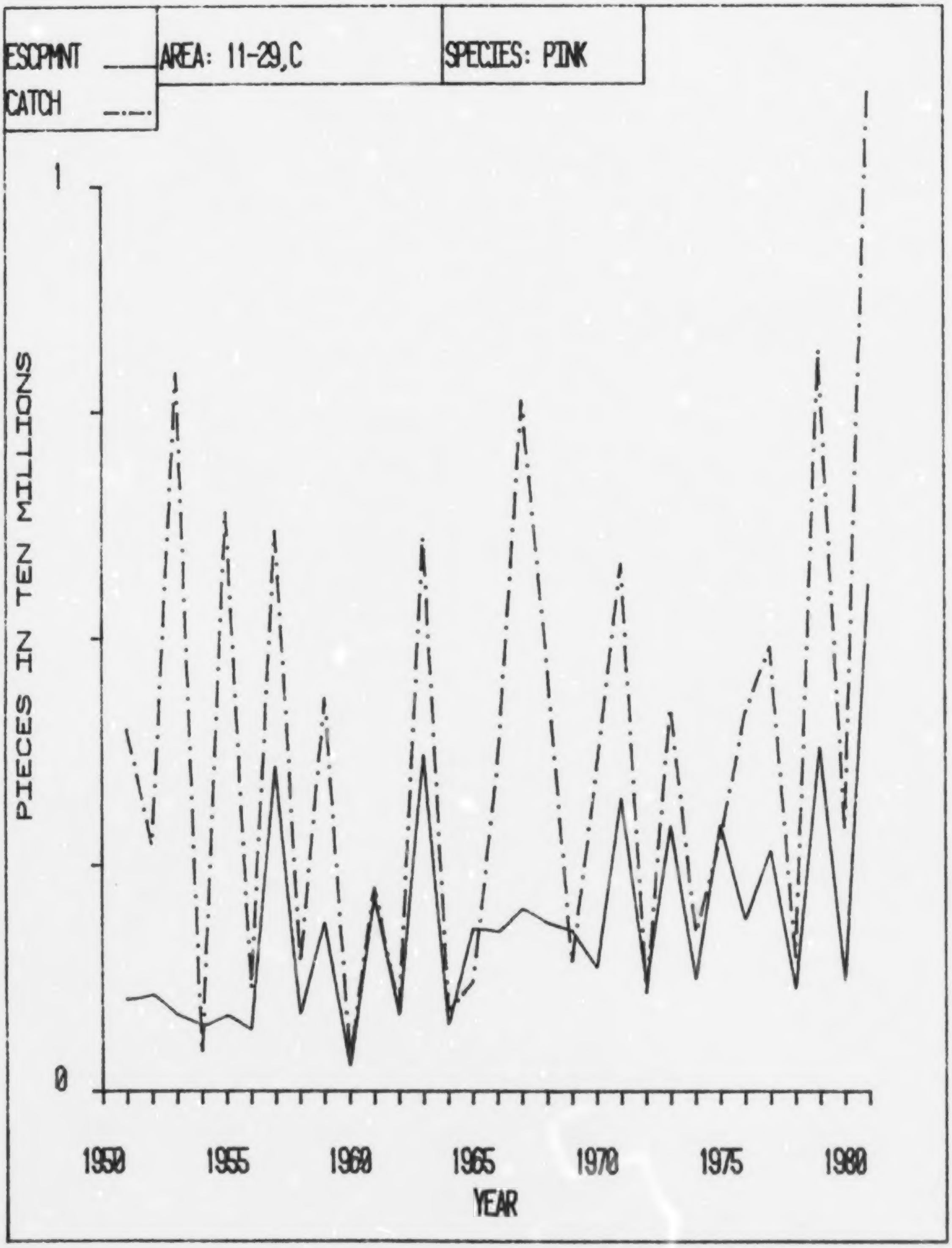

Fig. 12. Catch and escapement of South Coast and Fraser River pink salmon.

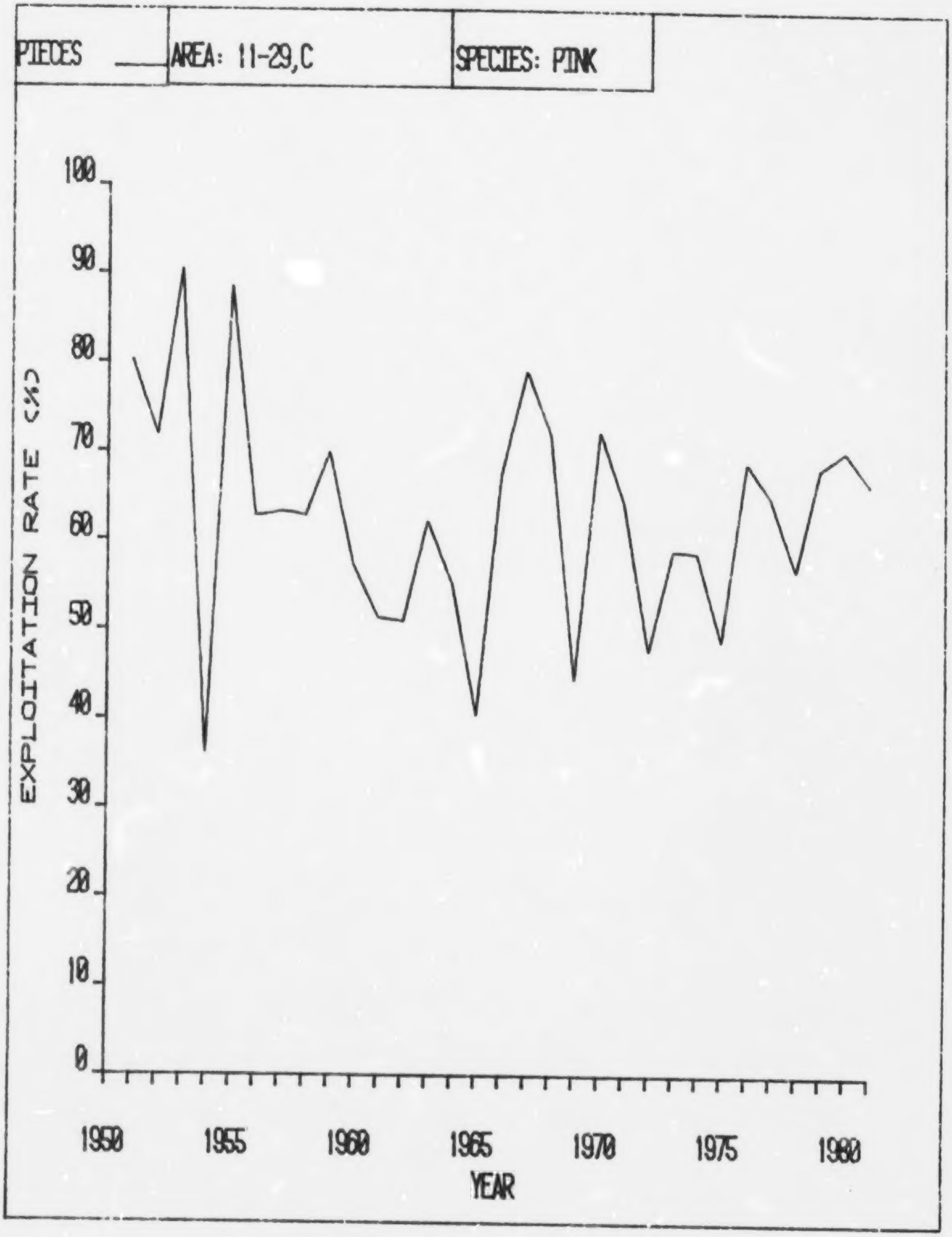

Fig. 13. Exploitation rate of South Coast and Fraser River pink salmon.

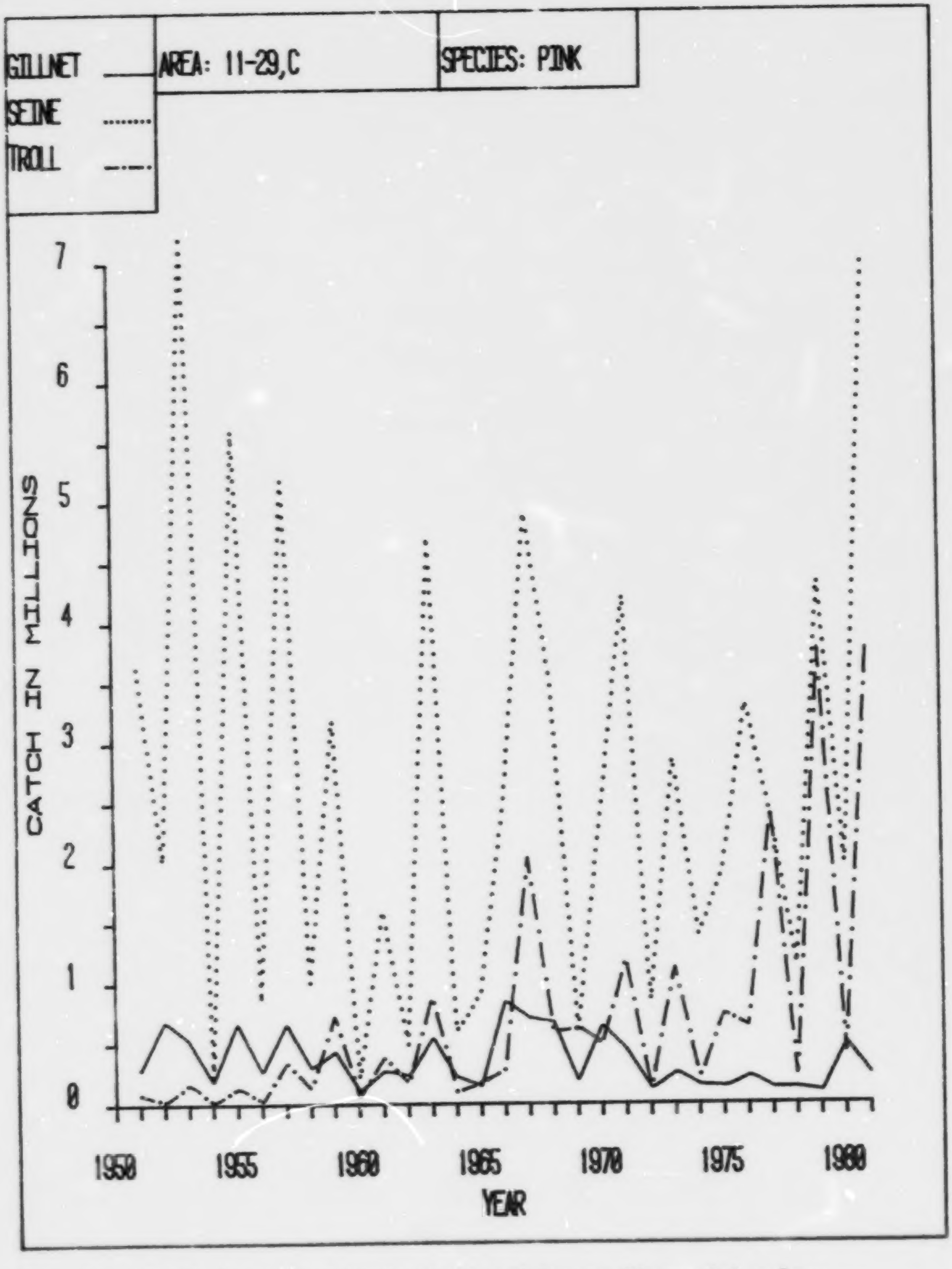

Fig. 14. Catch by gear of South Coast and Fraser River pink salmon.

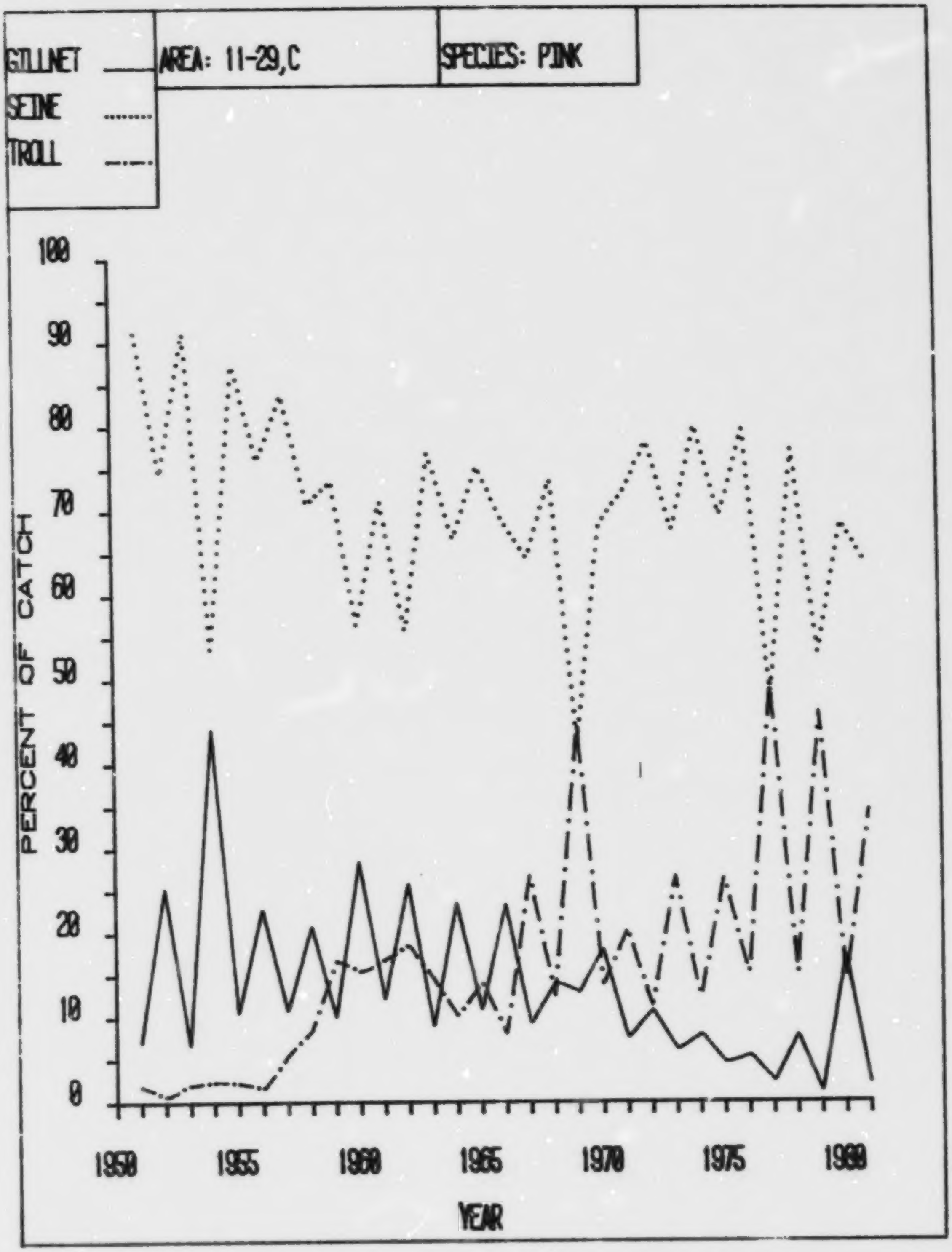

Fig. 15. Percent of total catch by gear of South Coast and Fraser River pink salmon.

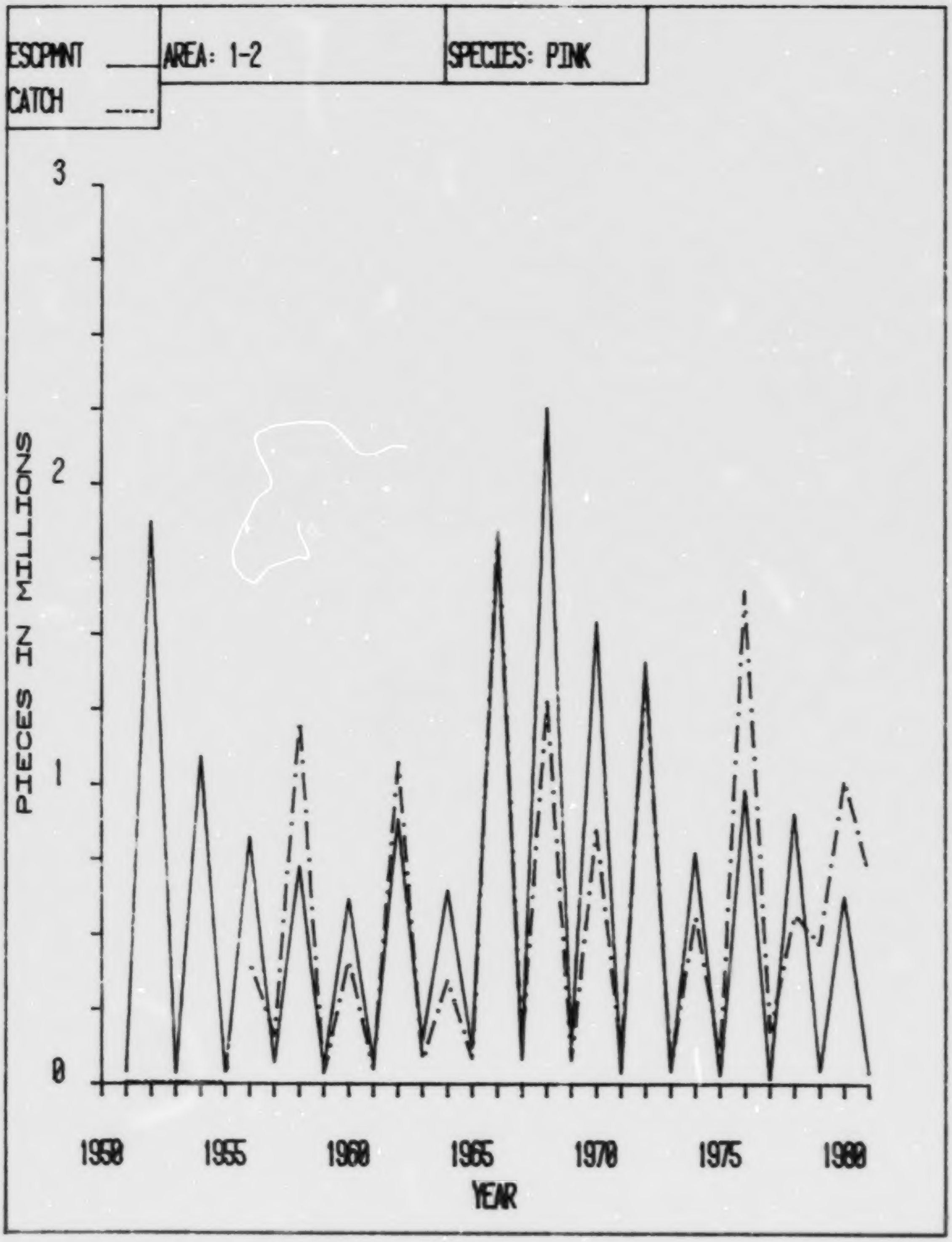

Fig. 16. Catch and escapement of Queen Charlotte Islands pink salmon.

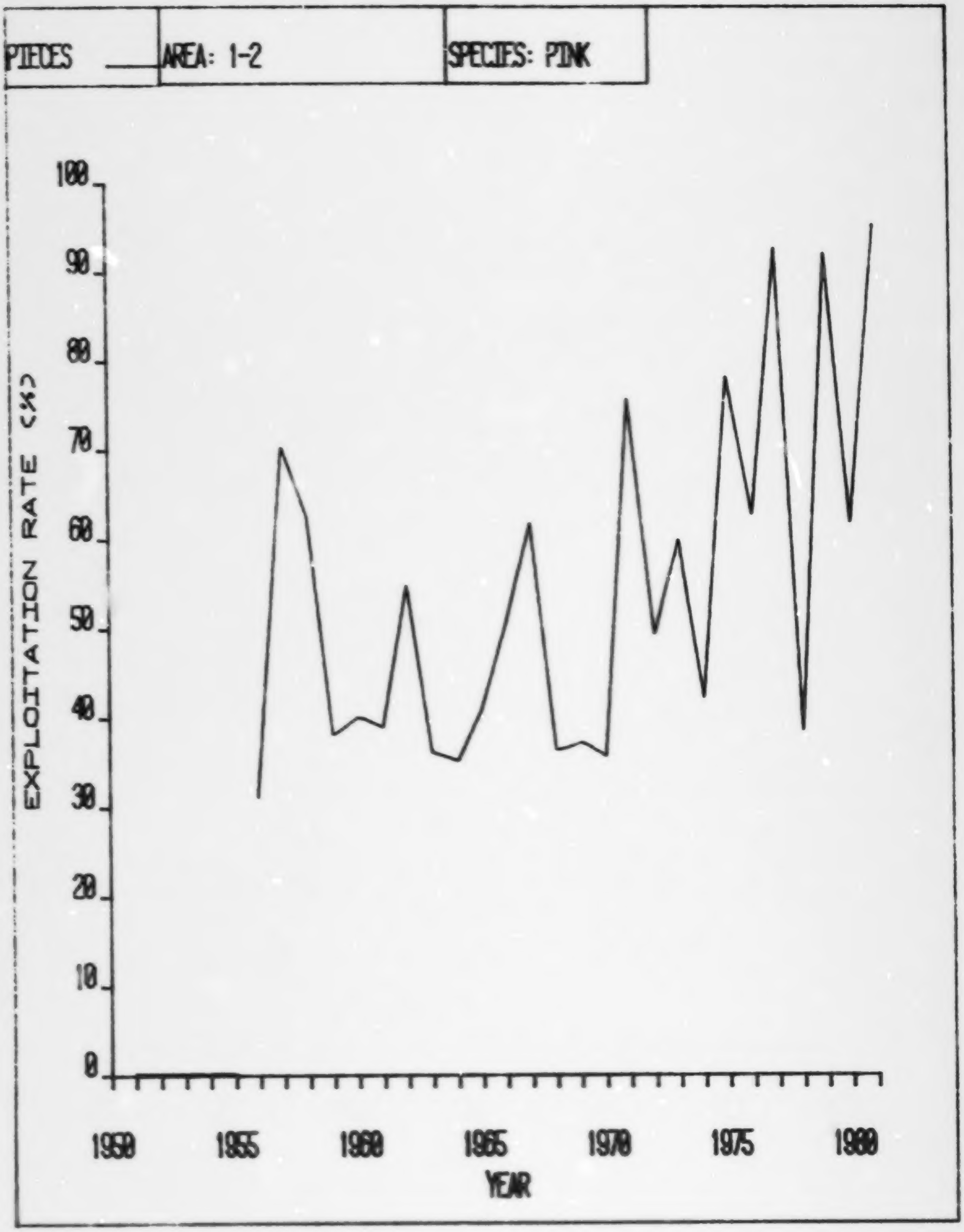

Fig. 17. Exploitation rate of Queen Charlotte Islands pink salmon.

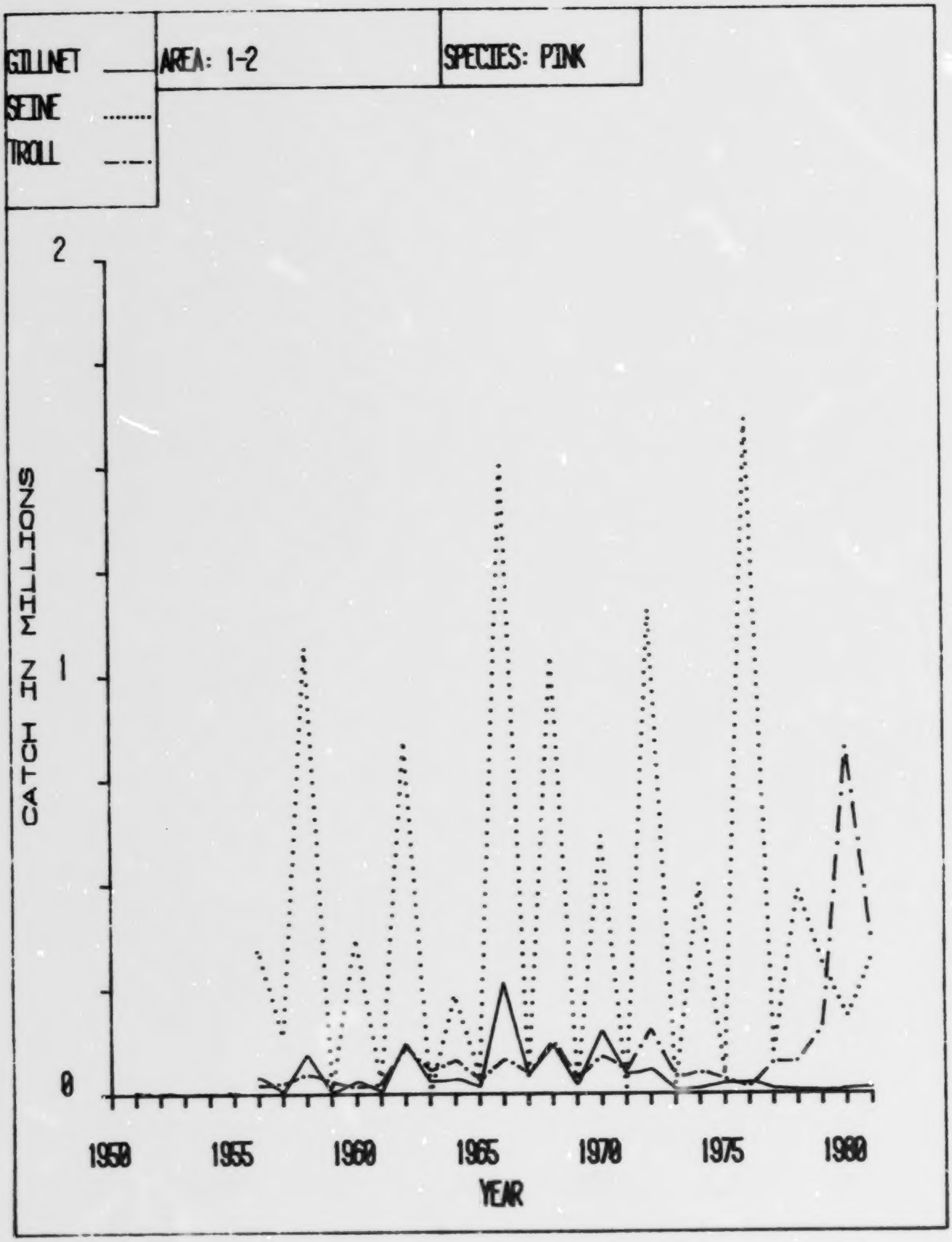

Fig. 18. Catch by gear of Queen Charlotte Islands pink salmon.

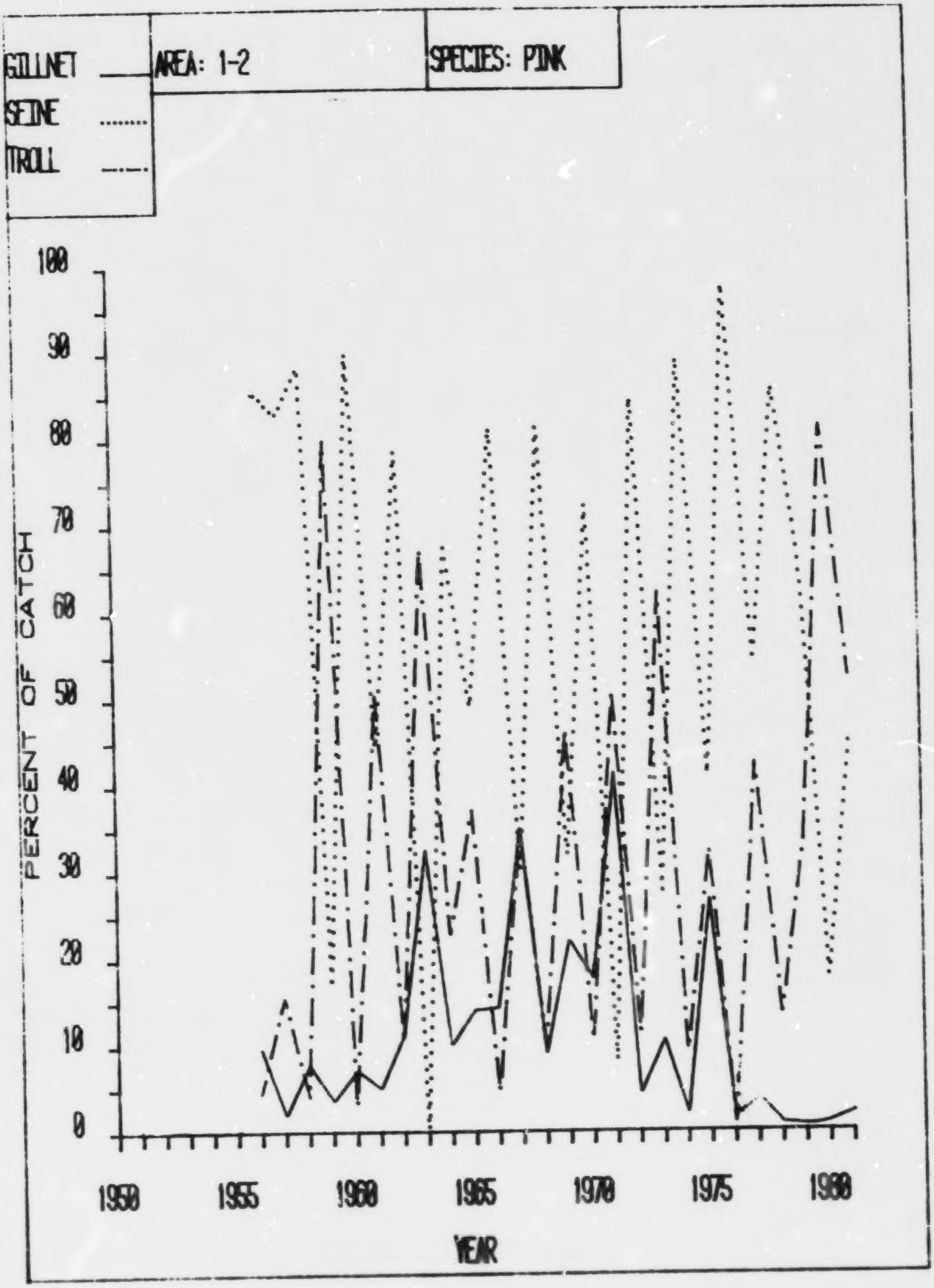

Fig. 19. Percent of total catch by gear of Queen Charlotte Islands pink salmon.

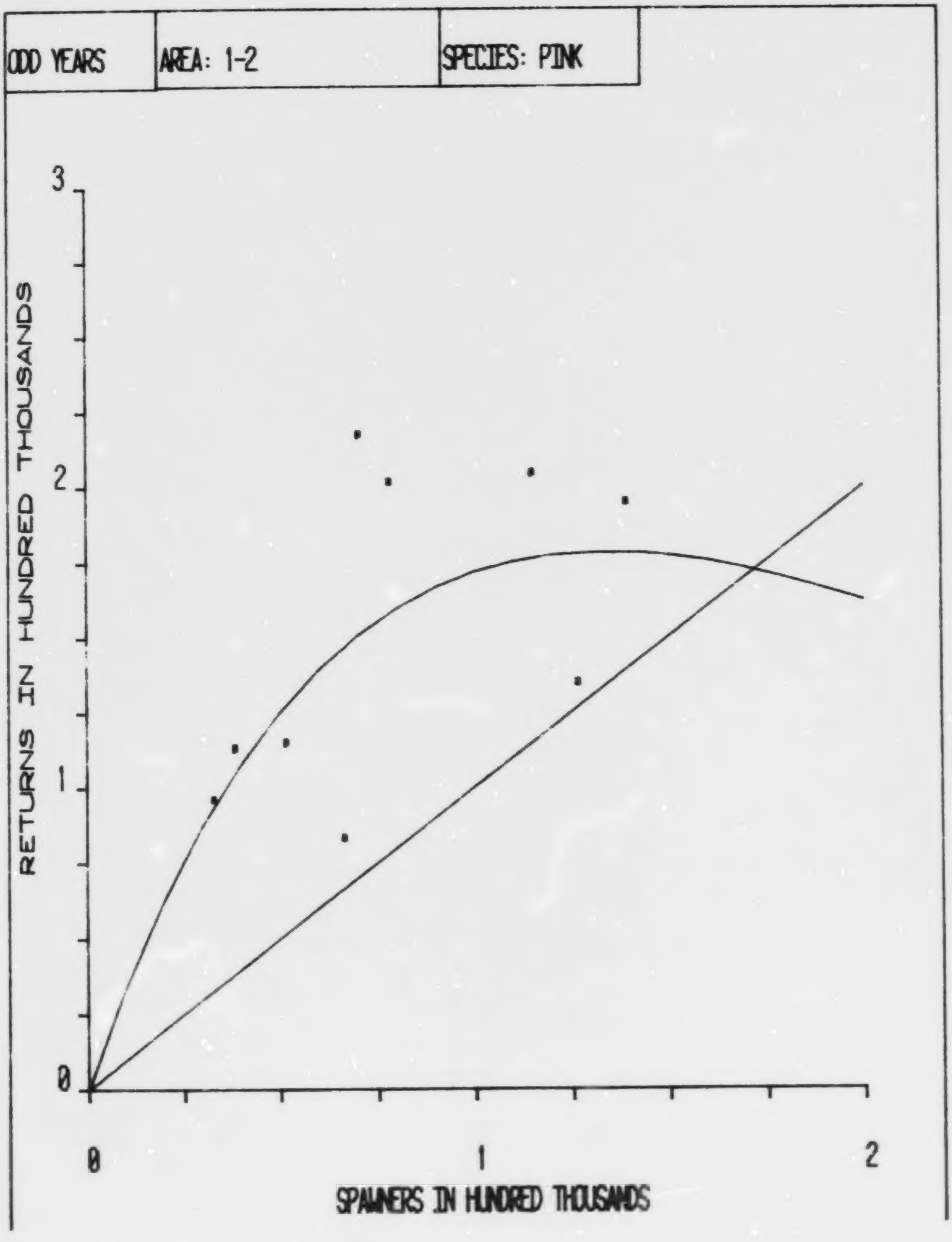

Fig. 20. Stock and recruitment relation for odd-numbered broodyears of Queen Charlotte Islands pink salmon, 1955-1979.

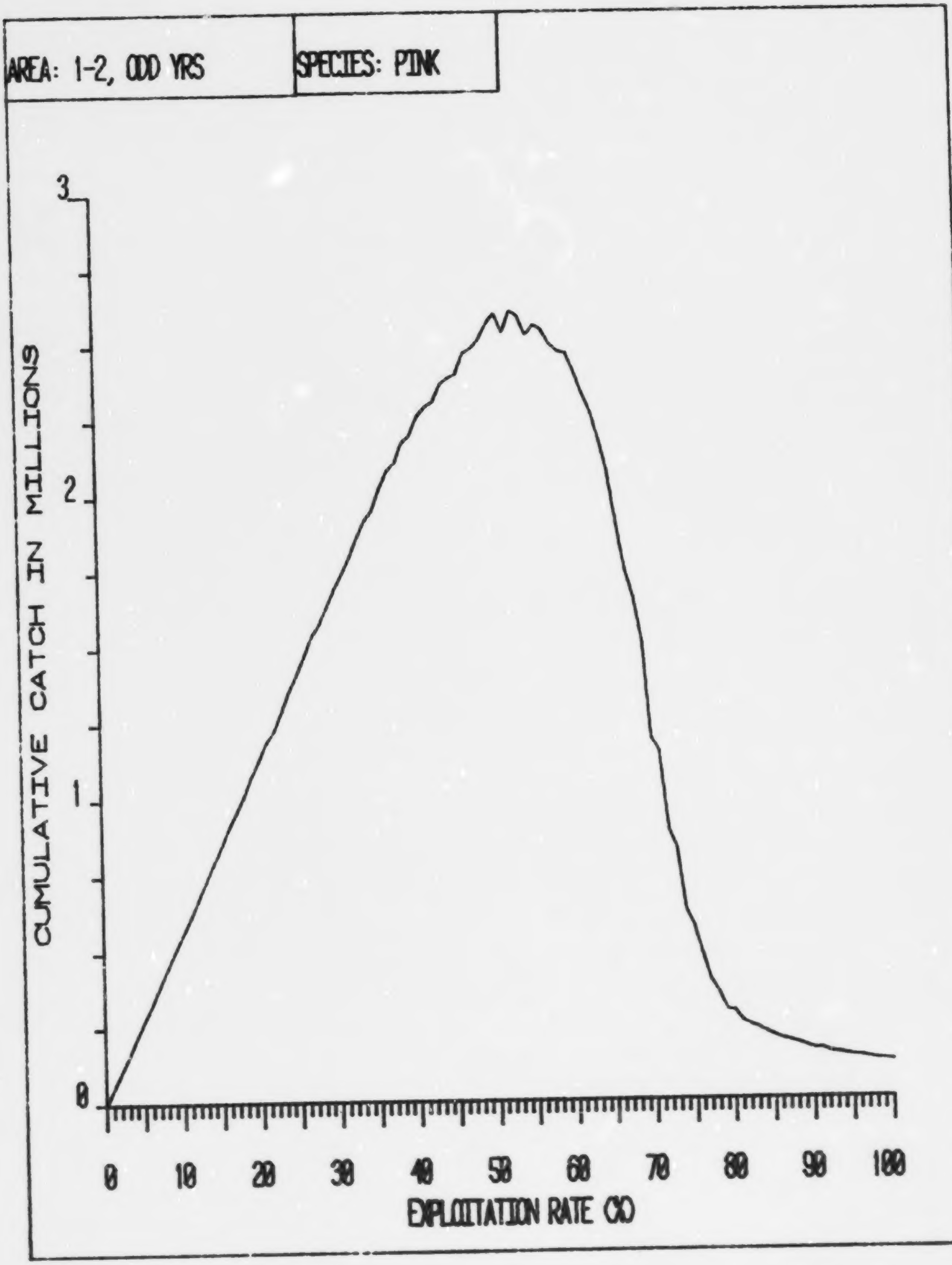

Fig. 21. Projected cumulative yield during 1961-2020 by harvesting at constant exploitation rate in each year for odd-year Queen Charlotte Islands pink salmon.

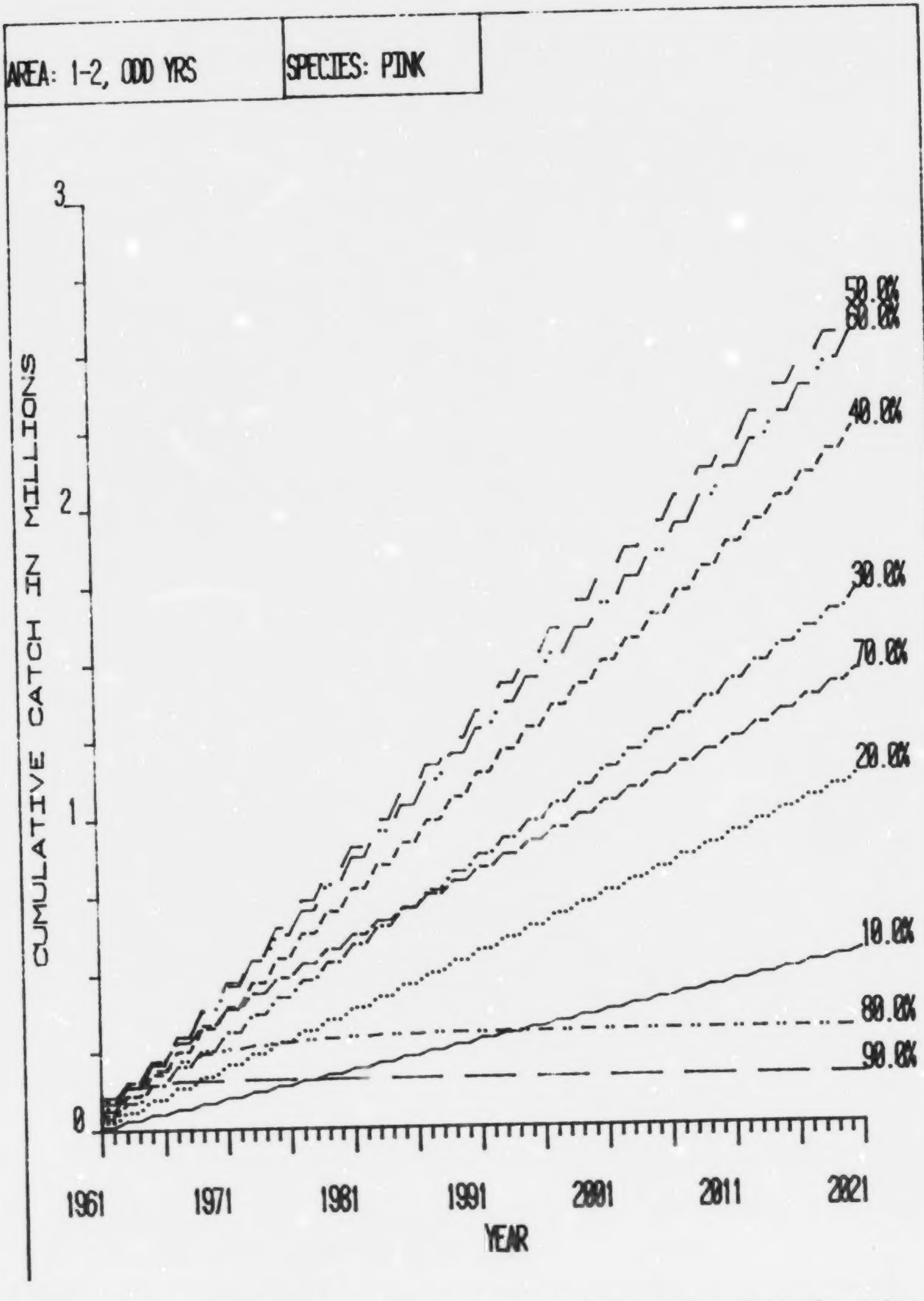

Fig. 22. Summary of yields under a 60-year projection of exploitation rates of 10-90% for odd-year Queen Charlotte Islands pink salmon.

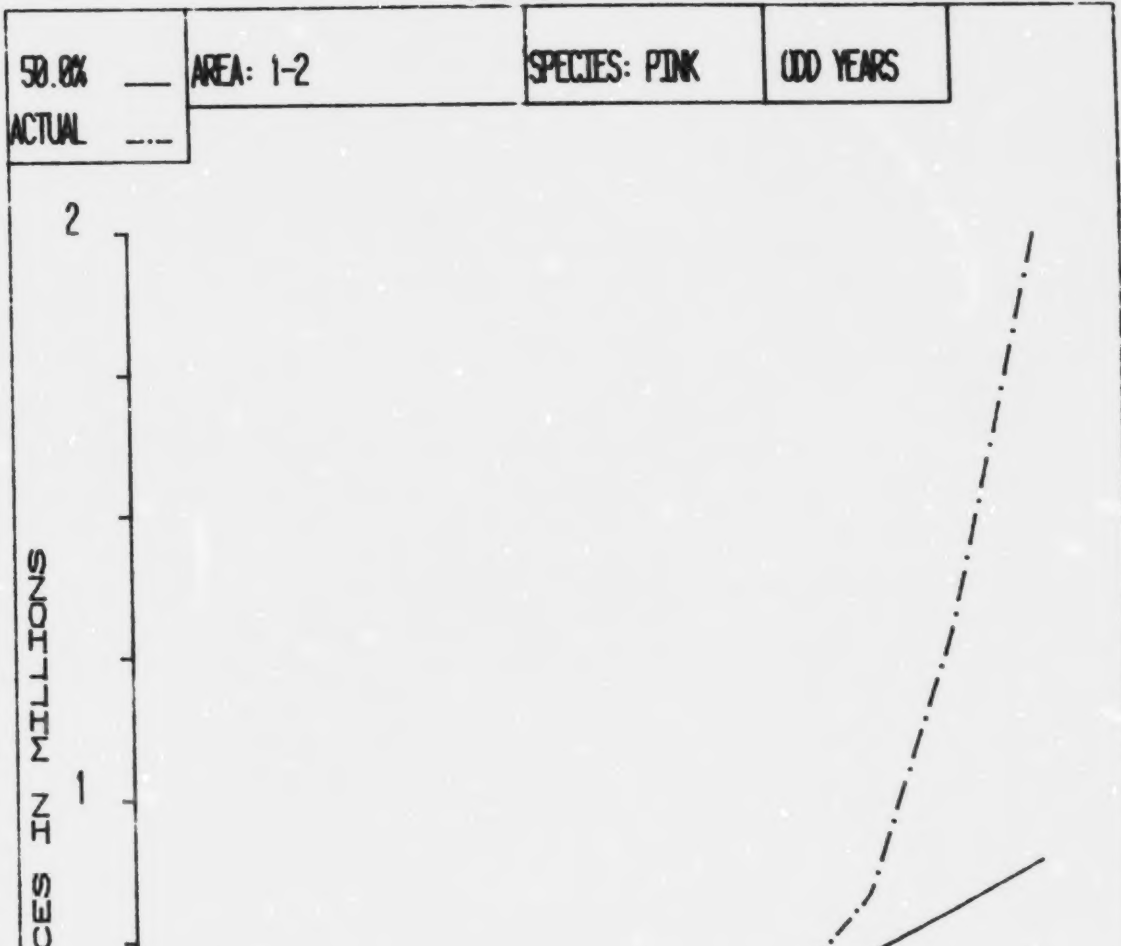

Fig. 23. Actual cumulative catch and projected cumulative catch under a policy of 50% annual exploitation rate during 1961-1981 of odd-year Queen Charlotte Islands pink salmon.

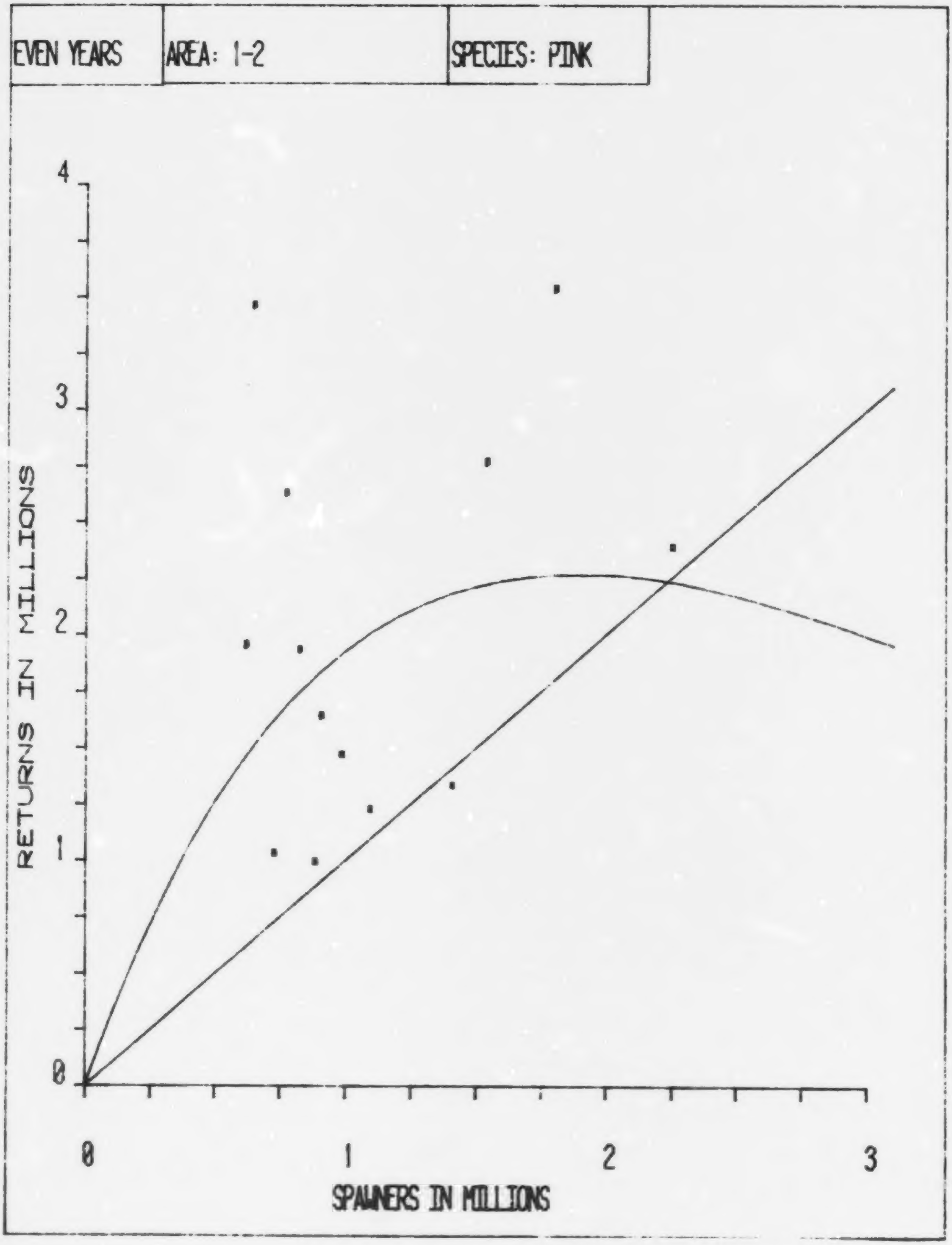

Fig. 24. Stock and recruitment relation for even-numbered broodyears of Queen Charlotte Islands pink salmon, 1954-1978.

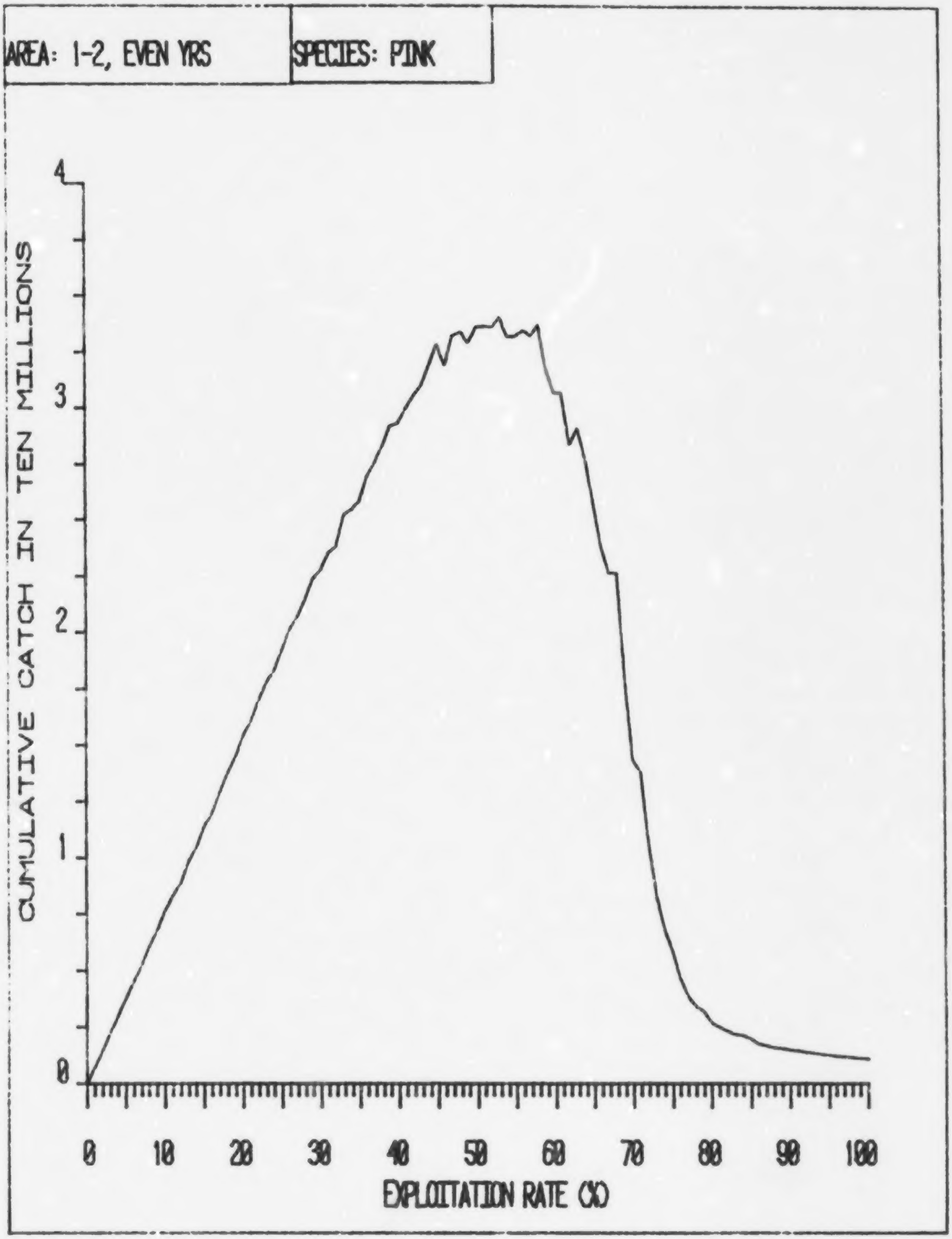

Fig. 25. Projected cumulative yield during 1960-2020 by harvesting at constant exploitation rate in each year for even-year Queen Charlotte Islands pink salmon.

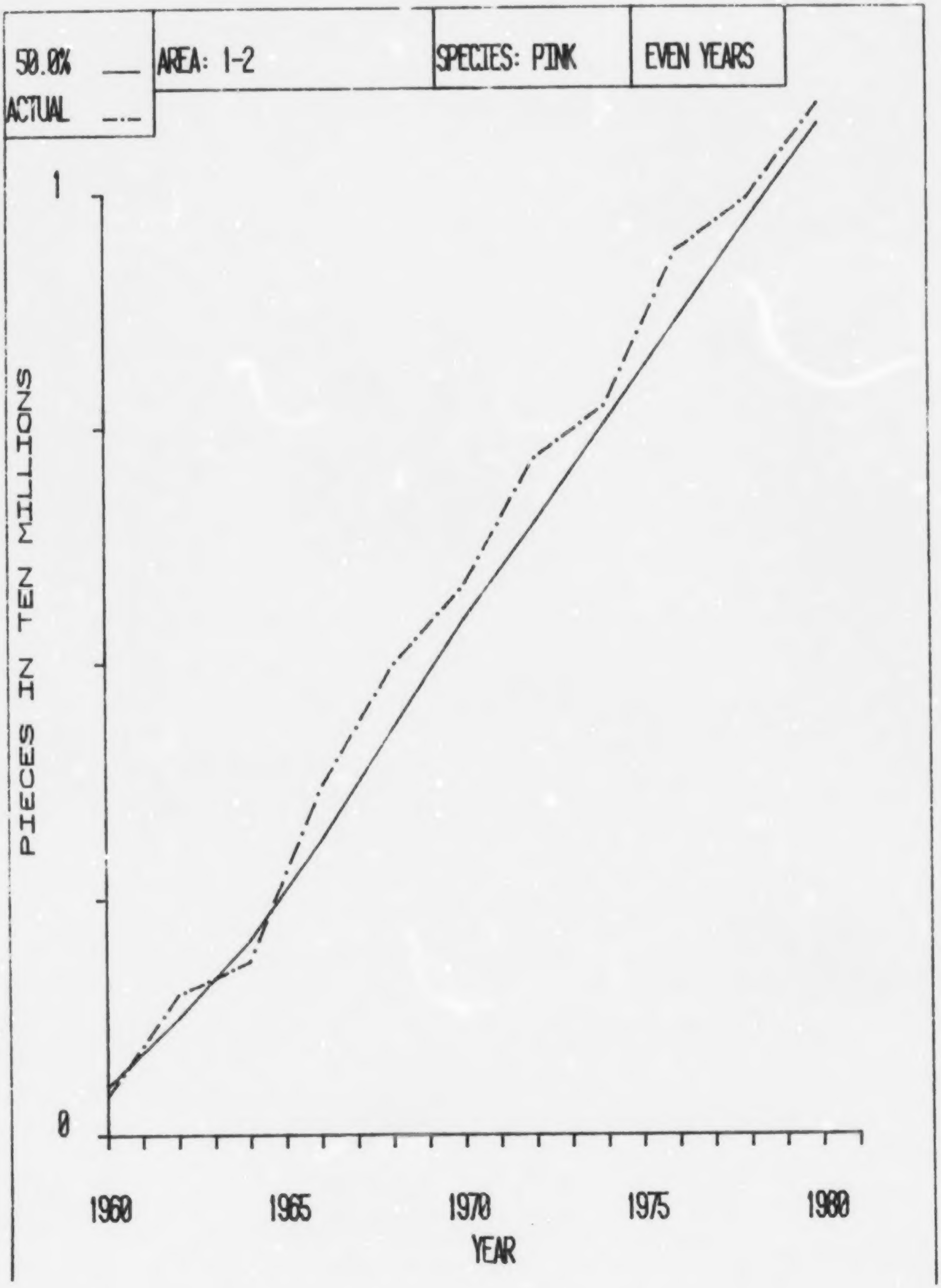

Fig. 26. Actual cumulative catch and projected cumulative catch under a policy of 50% annual exploitation rate during 1960-1980 of even-year Queen Charlotte Islands pink salmon.

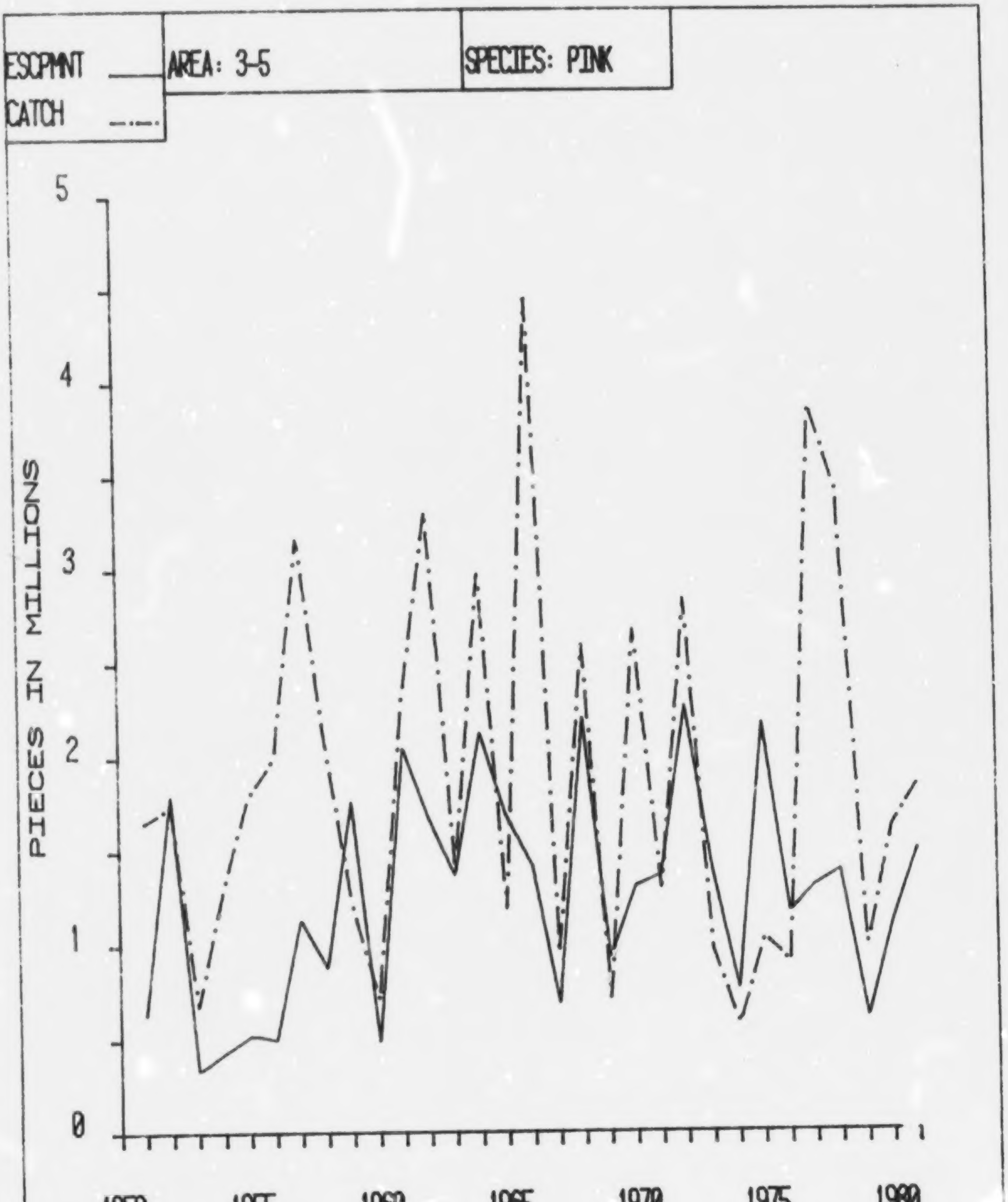

Fig. 27. Catch and escapement of North Coast pink salmon.

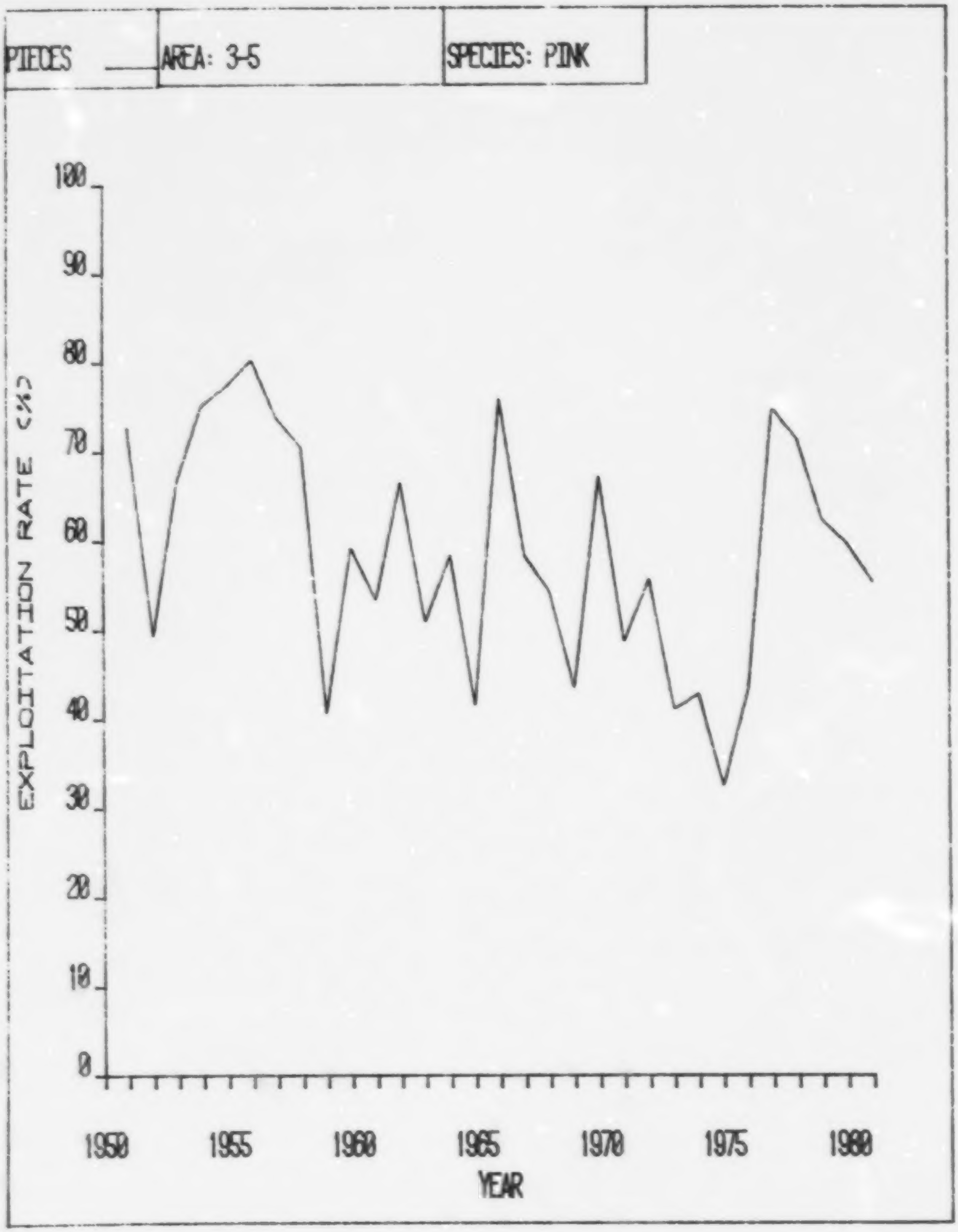

Fig. 28. Exploitation rates of North Coast pink salmon.

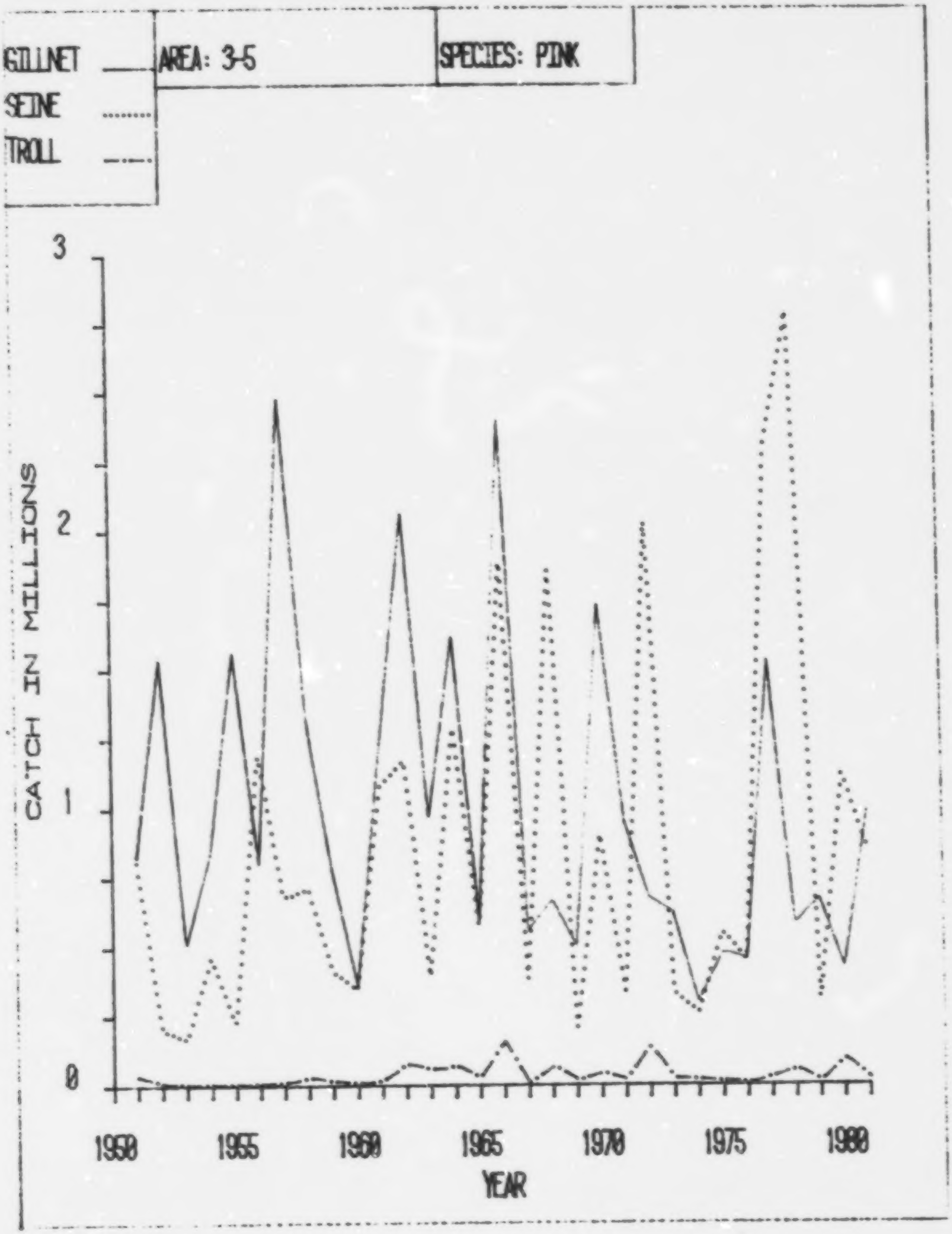

Fig. 29. Catch by gear of North Coast pink salmon.

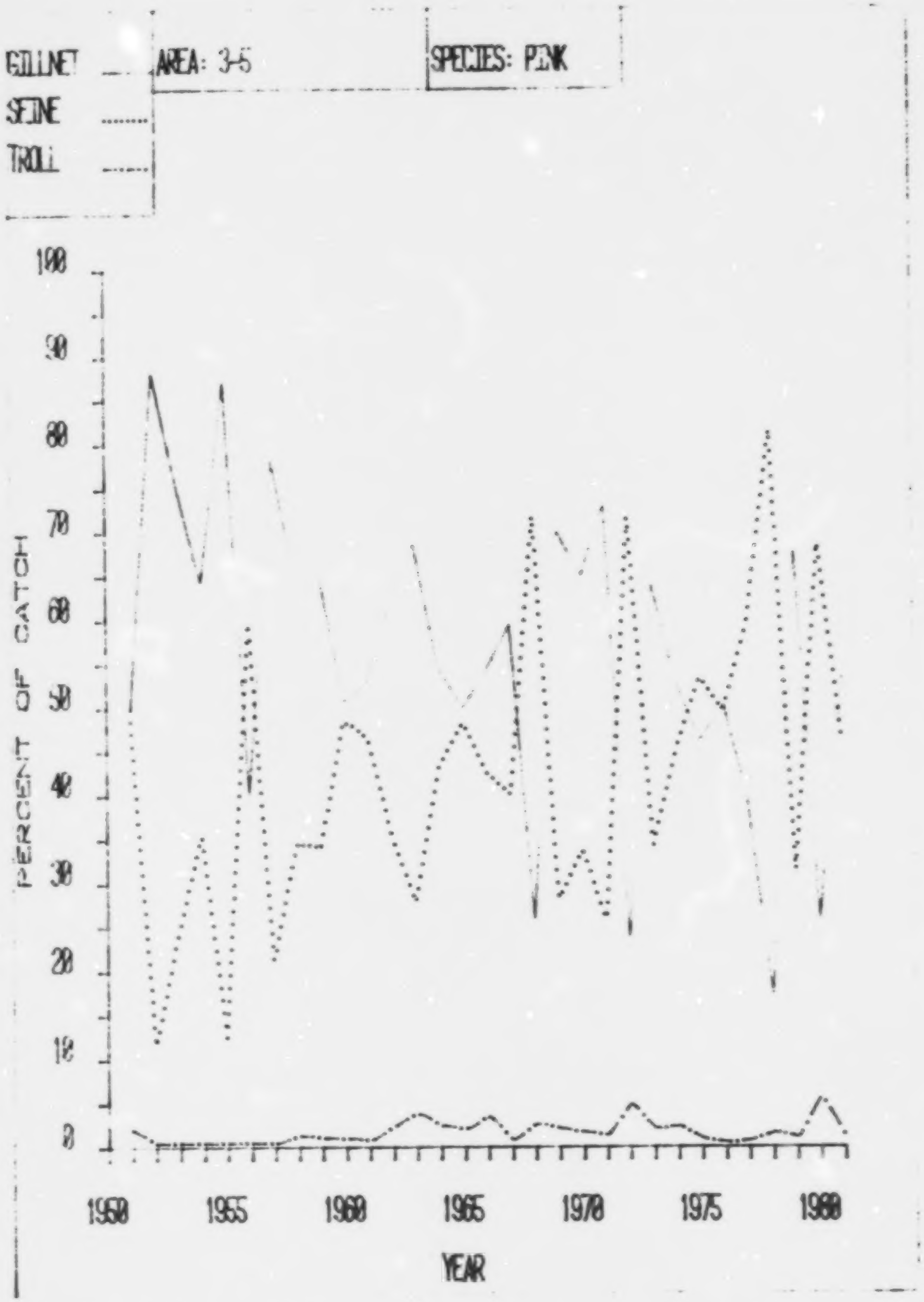

Fig. 30. Percent of total catch by gear of North Coast pink salmon.

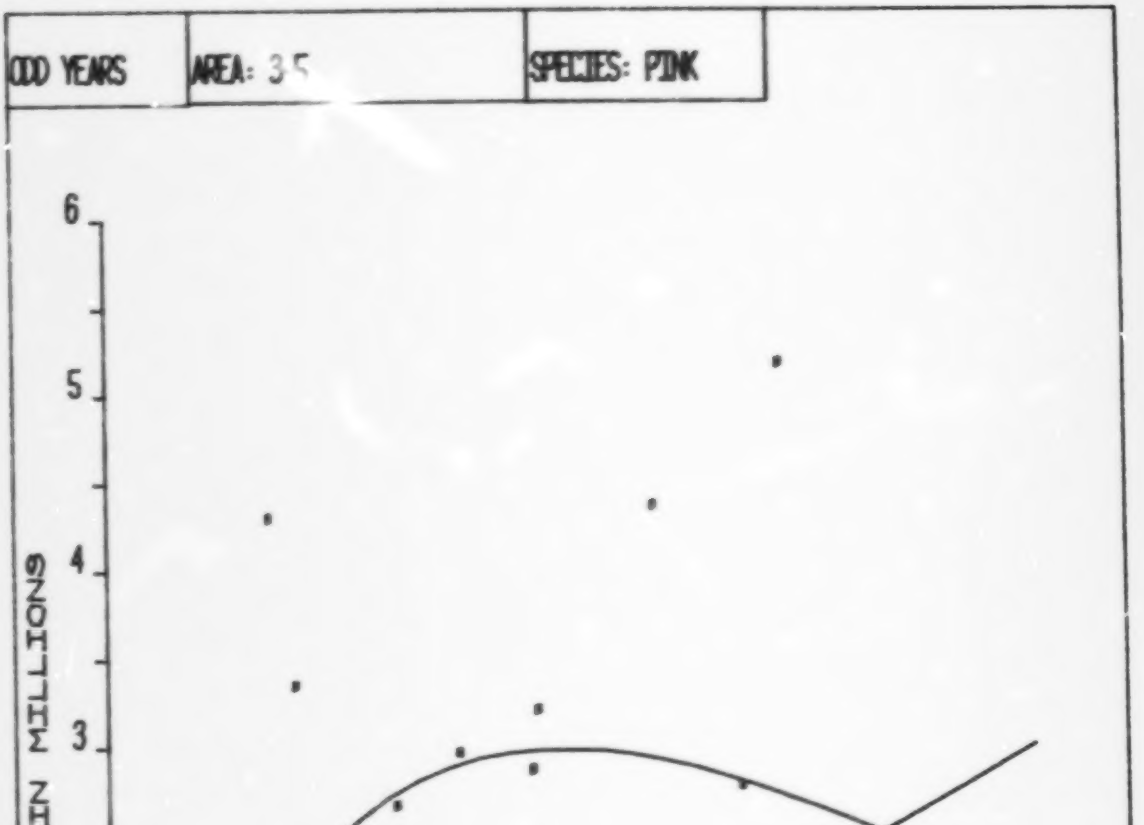

Fig. 31. Stock and recruitment relation for odd-numbered broodyears of North Coast pink salmon, 1949-1979.

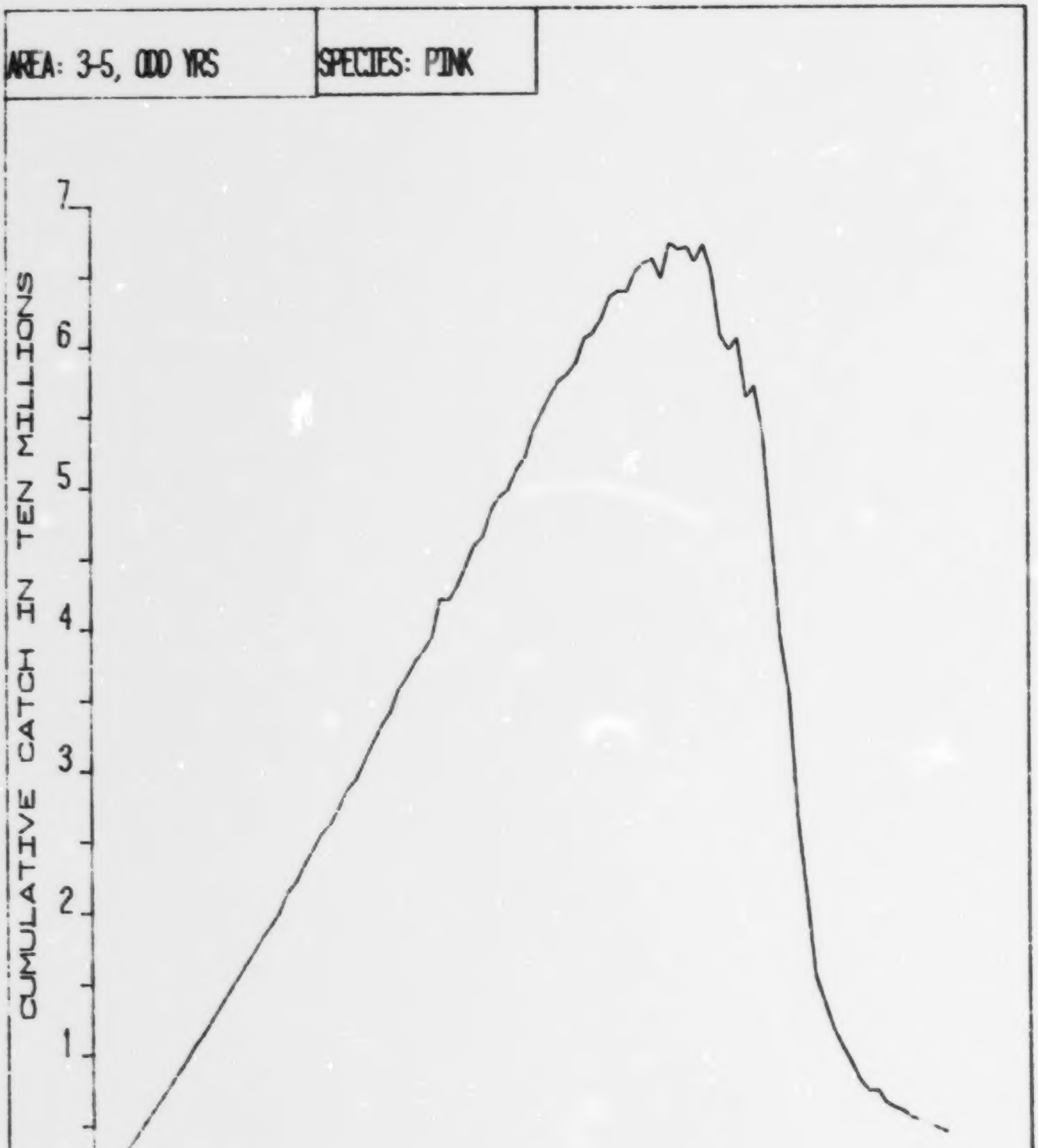

Fig. 32. Projected cumulative yield during 1961-2020 by harvesting at constant exploitation rate in each year for odd-year North Coast pink salmon.

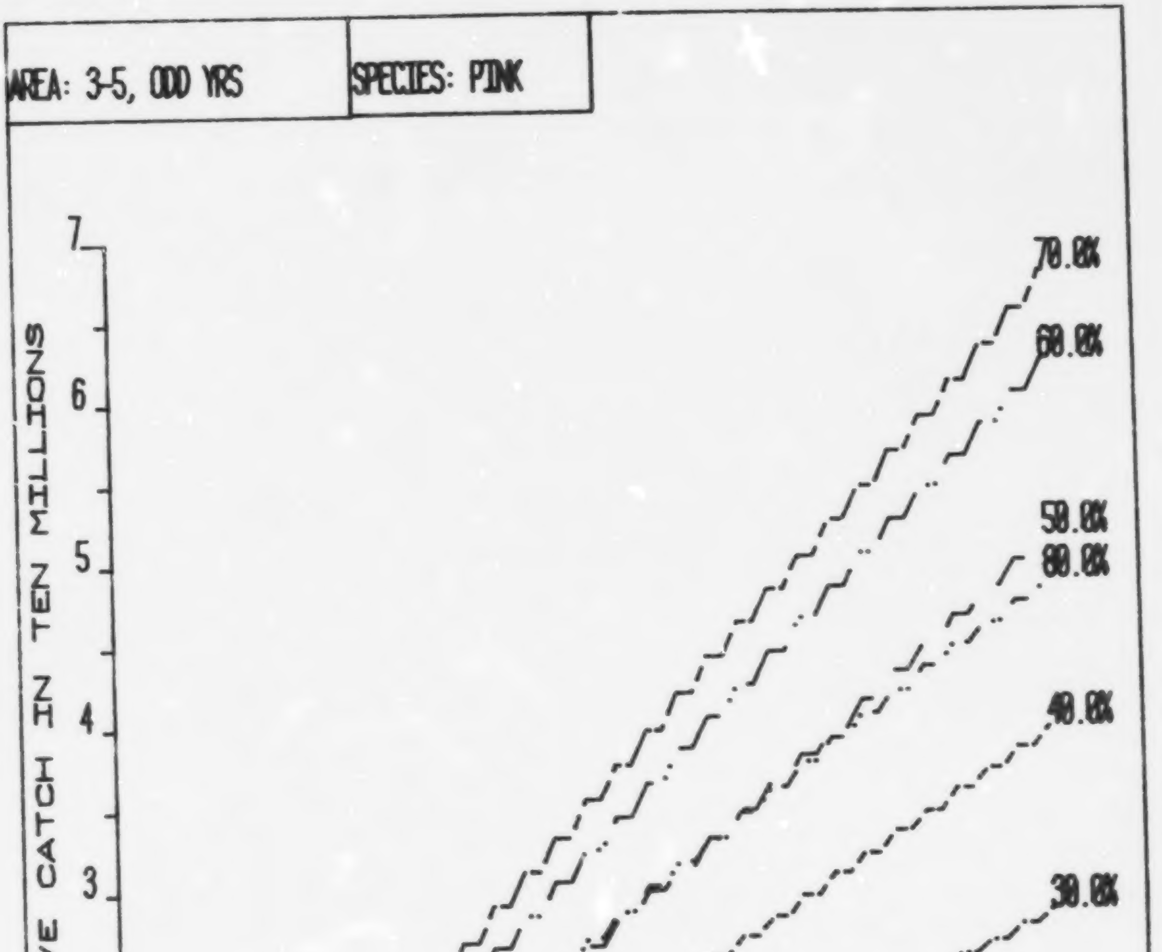

Fig. 33. Summary of yields under a 60-year projection of exploitation rates of 10-90% for odd-year North Coast pink salmon.

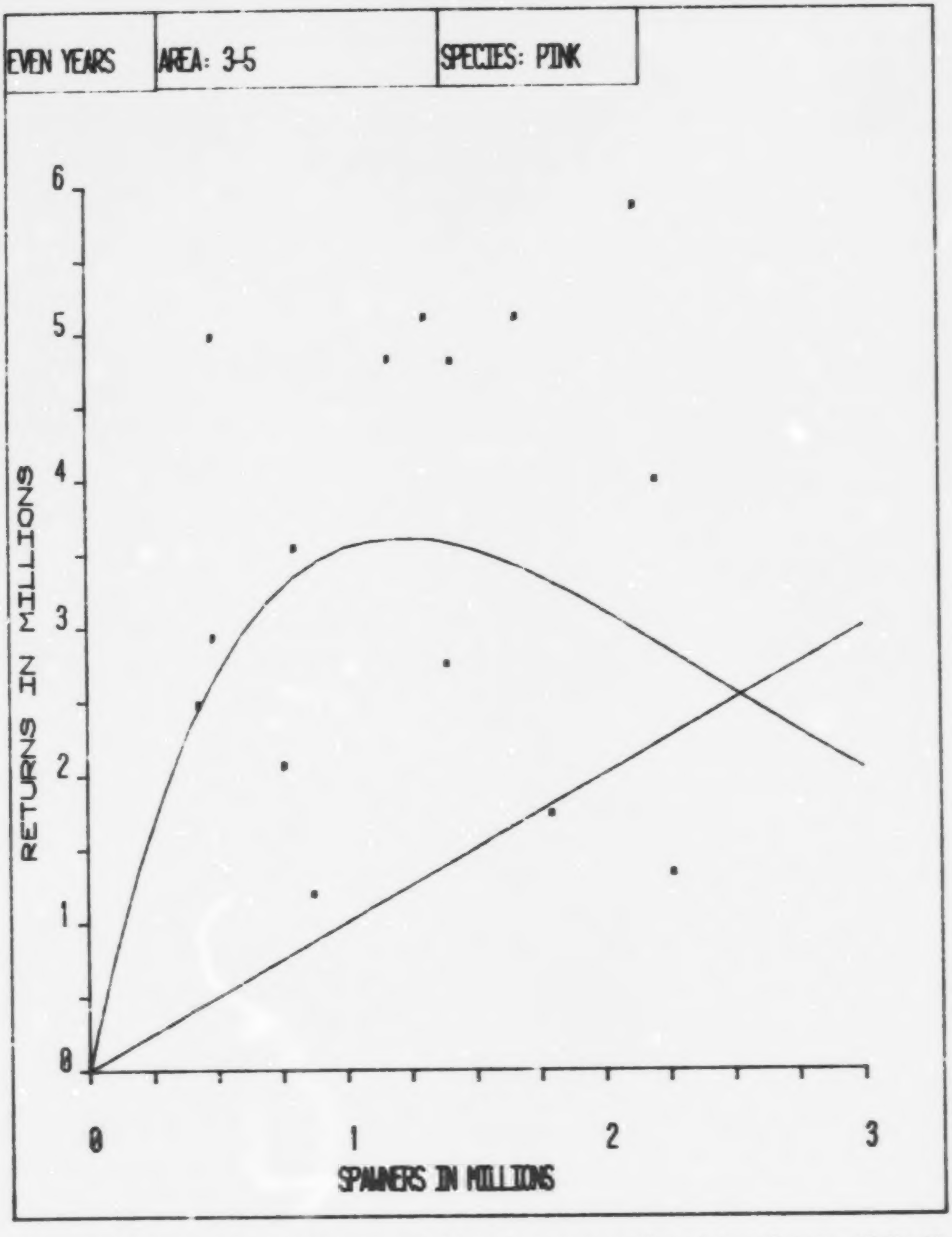

Fig. 34. Stock and recruitment relation for even-numbered broodyears of North Coast pink salmon, 1950-1978.

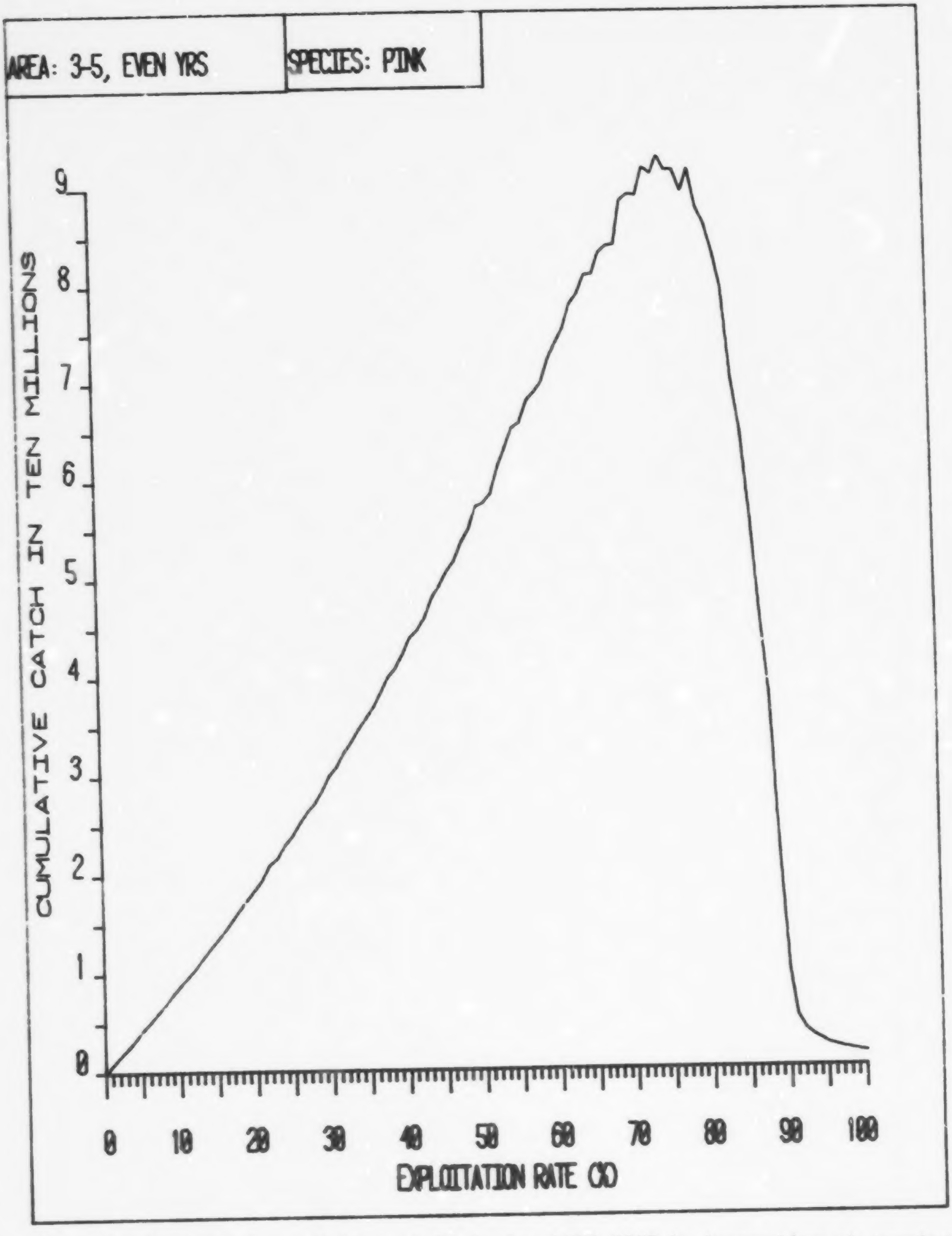

Fig. 35. Projected cumulative yield during 1960-2020 by harvesting at constant exploitation rate in each year for even-year North Coast pink salmon.

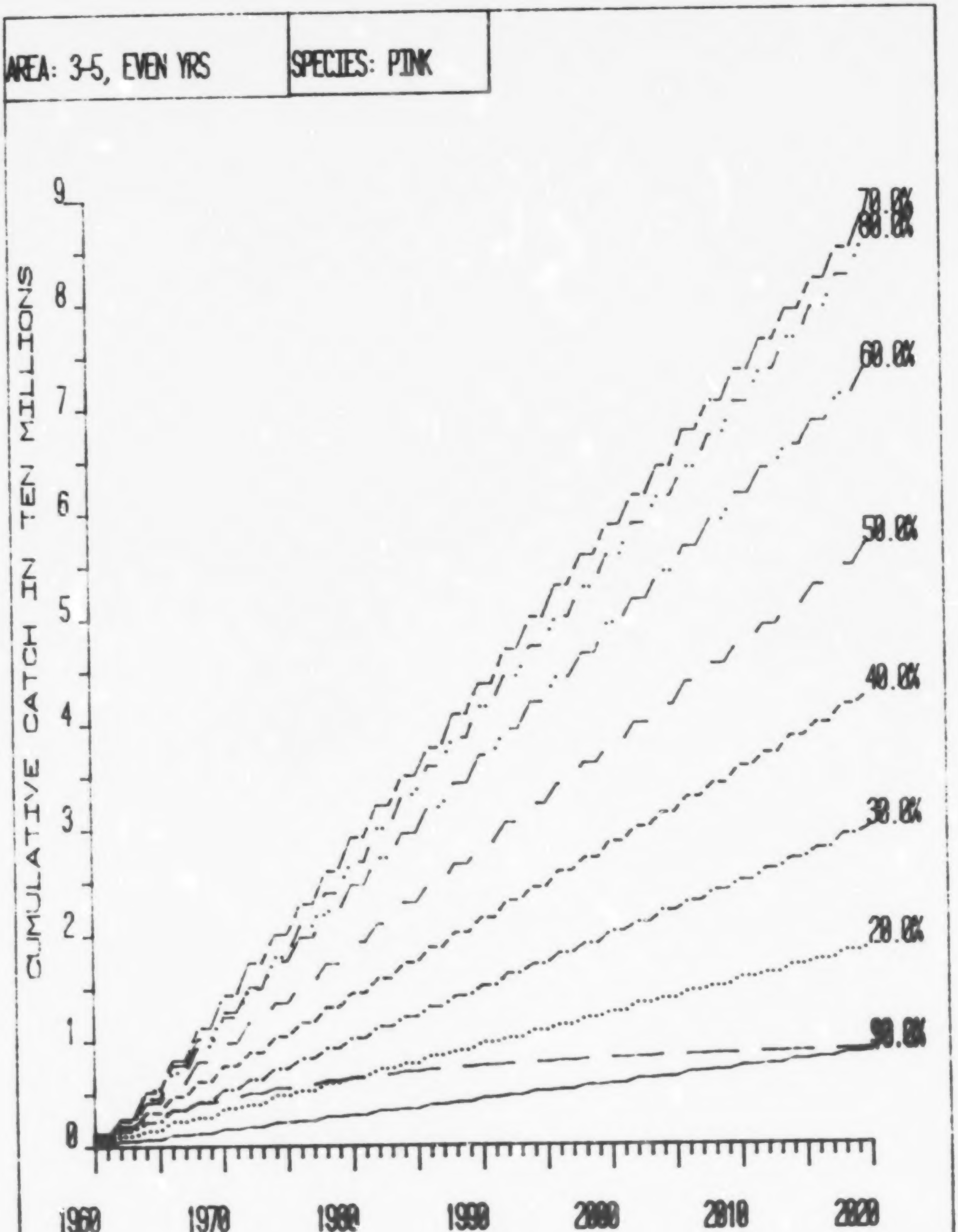

Fig. 36. Summary of yields under a 60-year projection of exploitation rates of 10-90% for even-year North Coast pink salmon.

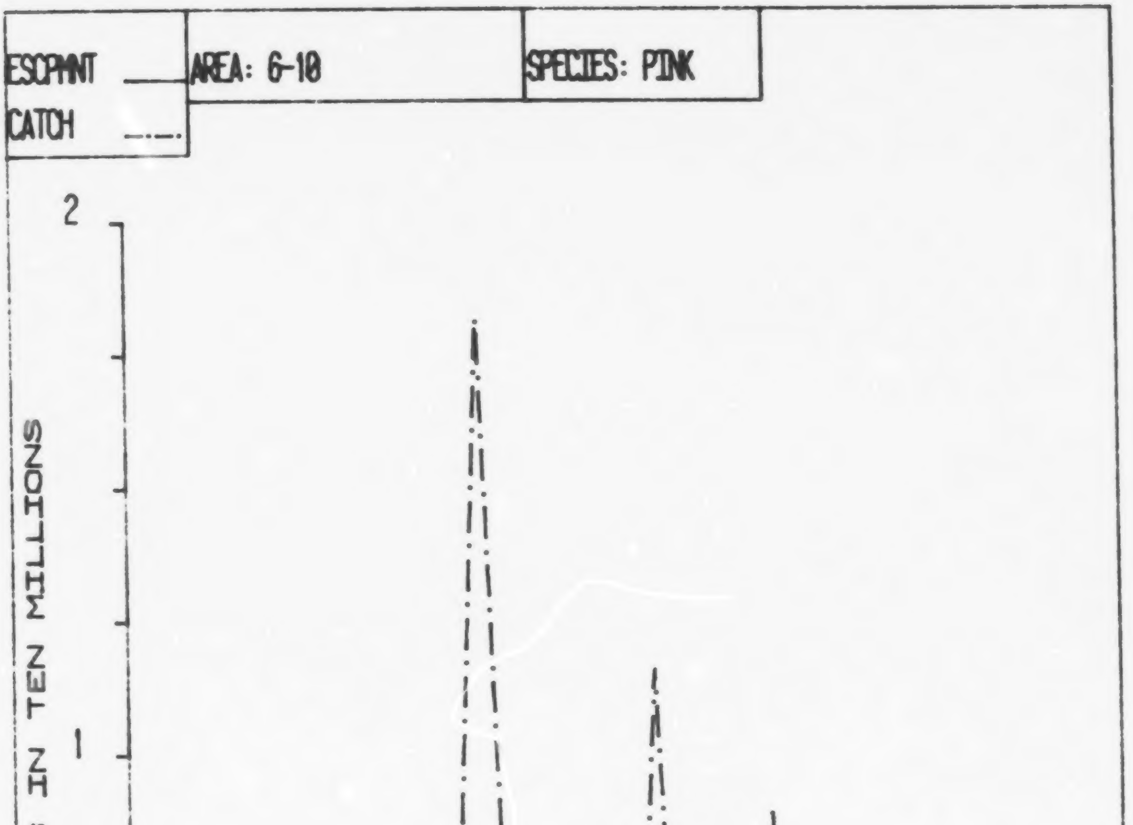

Fig. 37. Catch and escapement of Central Coast pink salmon.

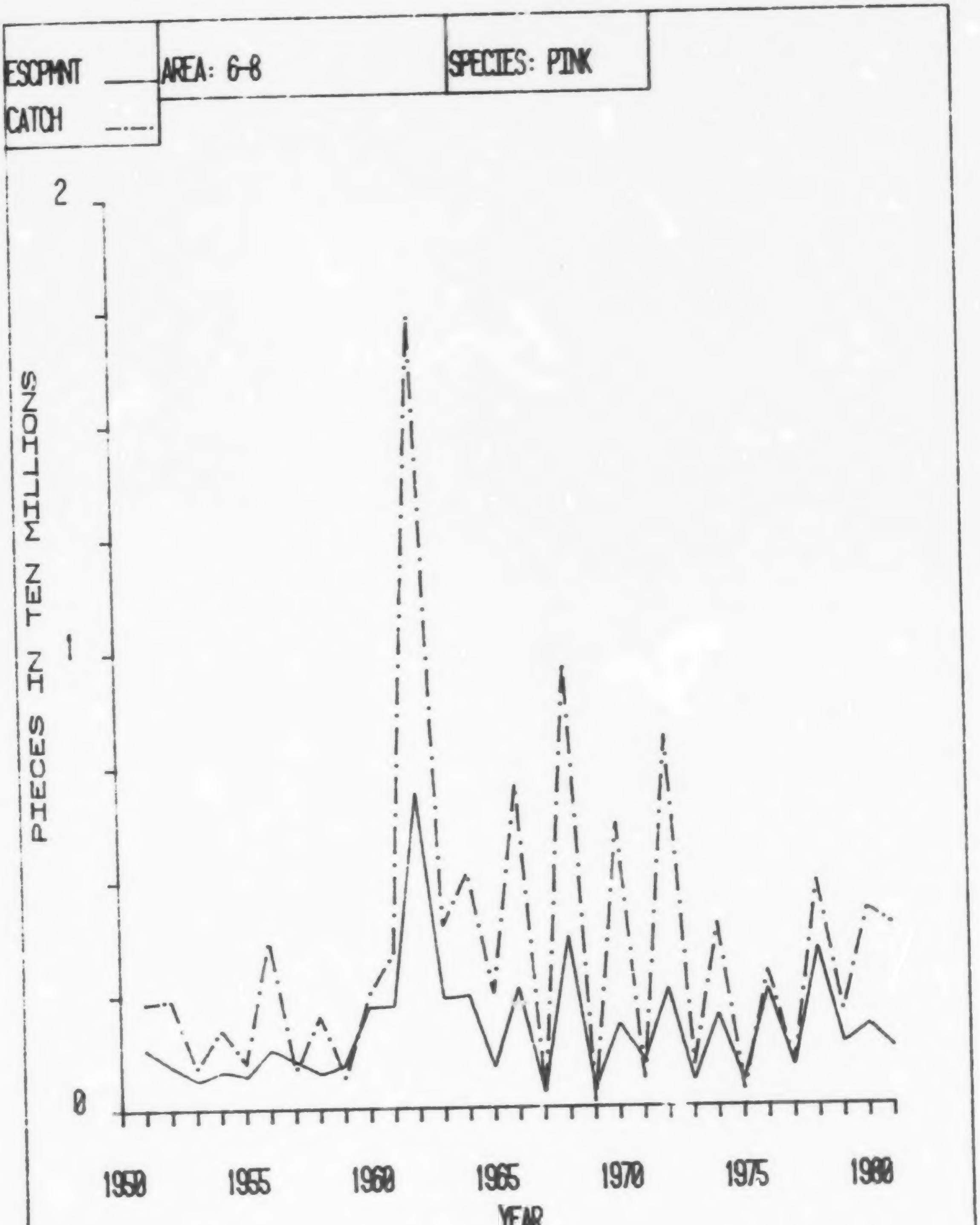

Fig. 38. Catch and escapement of pink salmon in Statistical Areas 6-8.

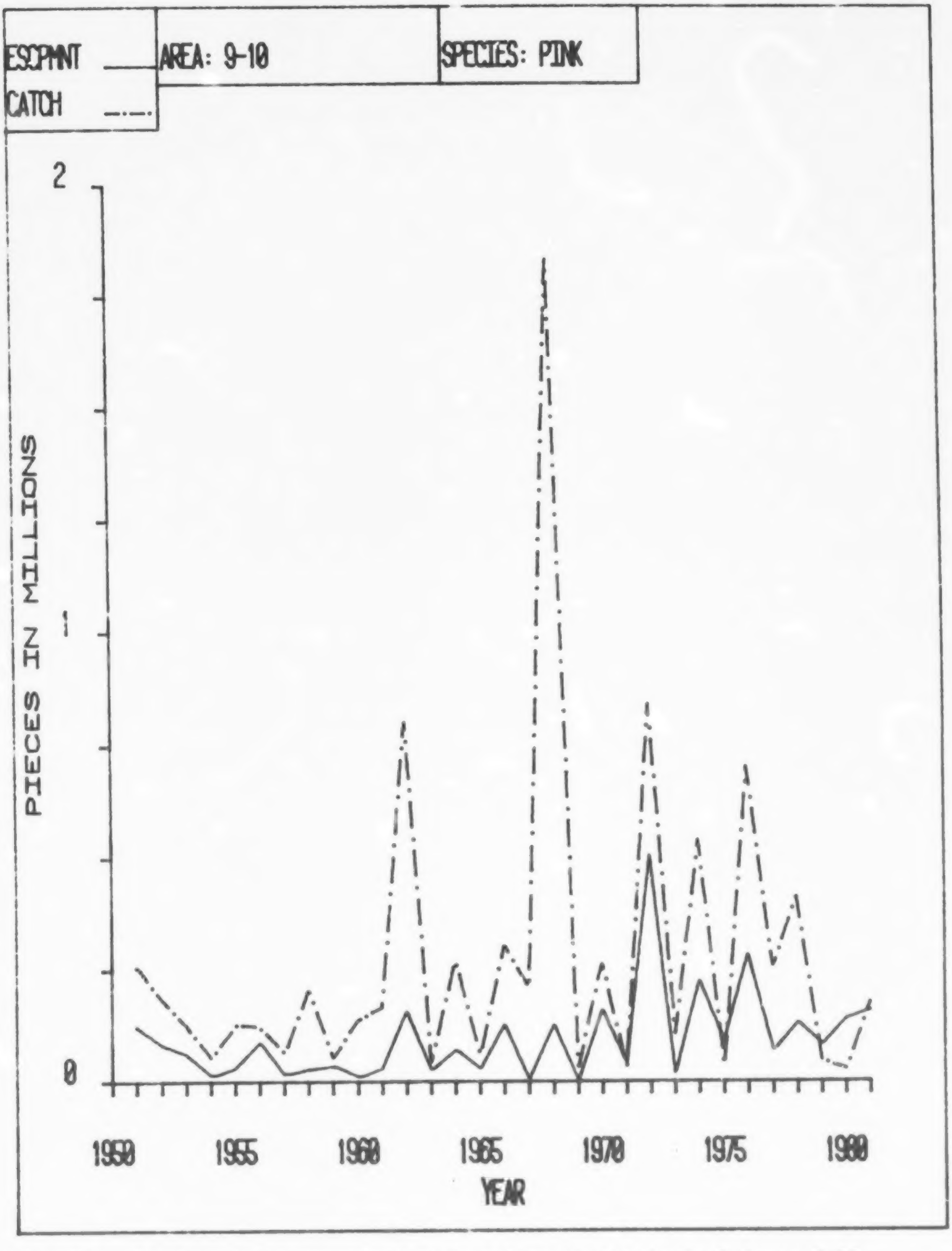

Fig. 39. Catch and escapement of pink salmon in Statistical Areas 9-10.

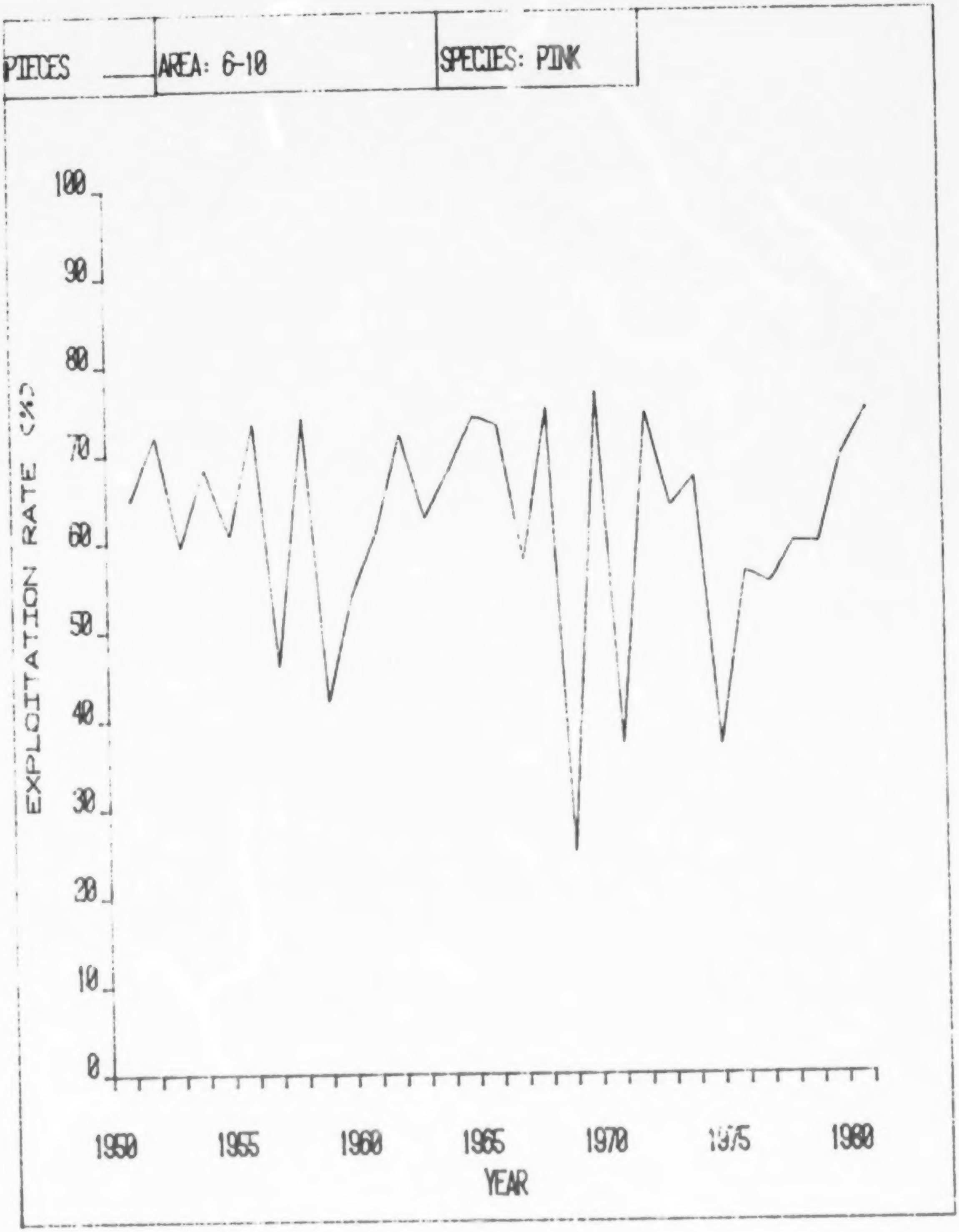

Fig. 40. Exploitation rate of Central Coast pink salmon.

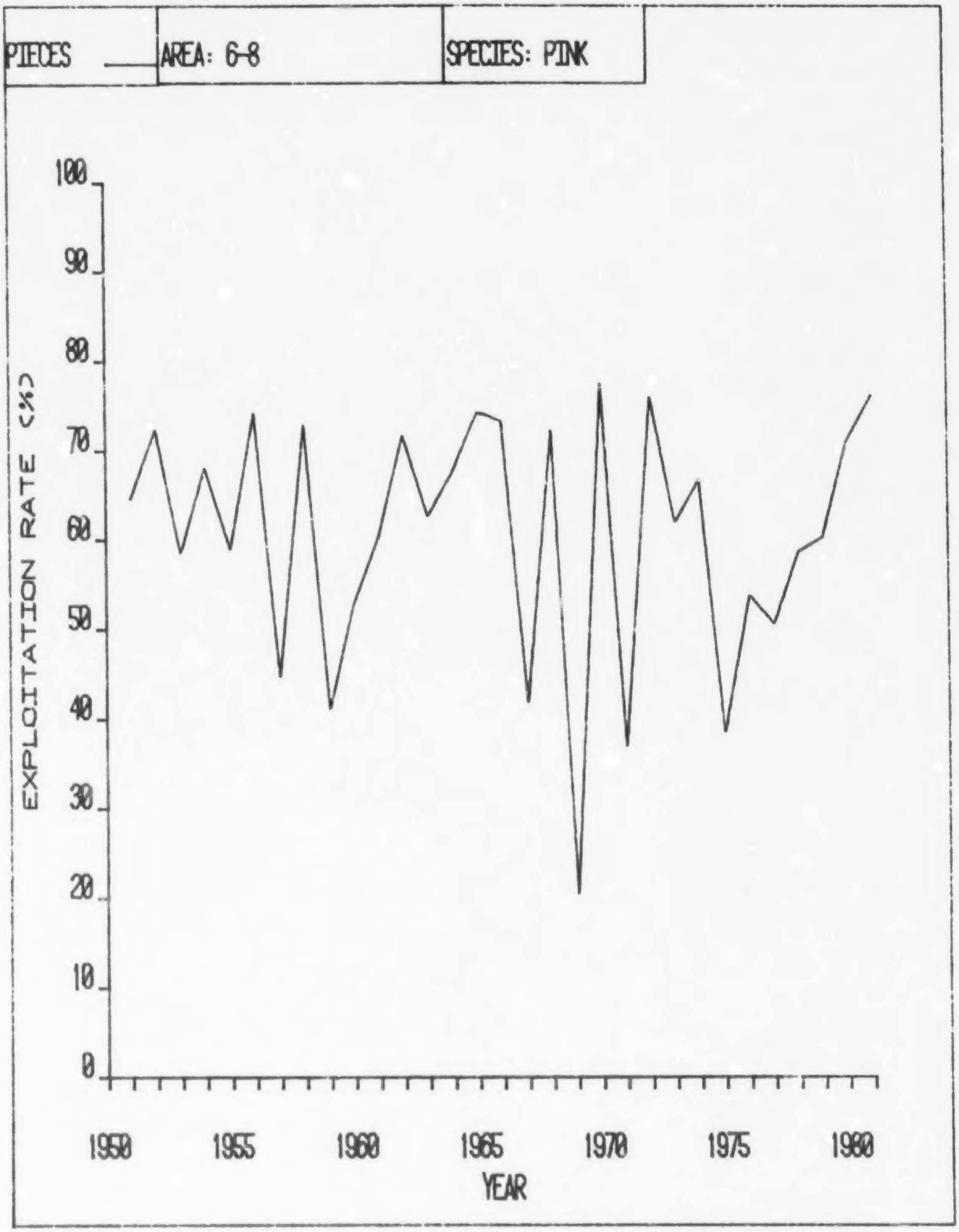

Fig. 41. Exploitation rate of pink salmon in Statistical Areas 6-8.

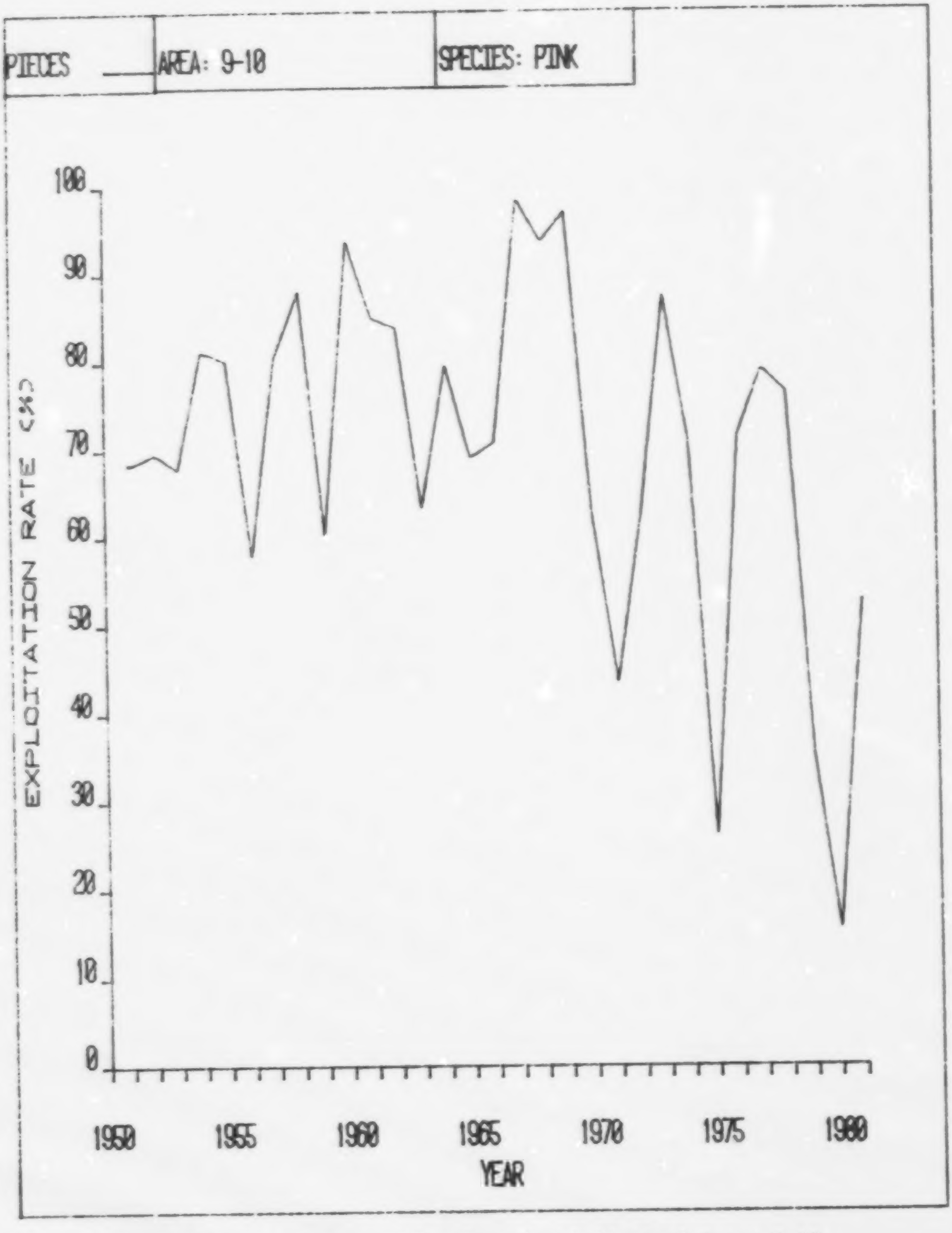

Fig. 42. Exploitation rate of pink salmon in Statistical Areas 9-10

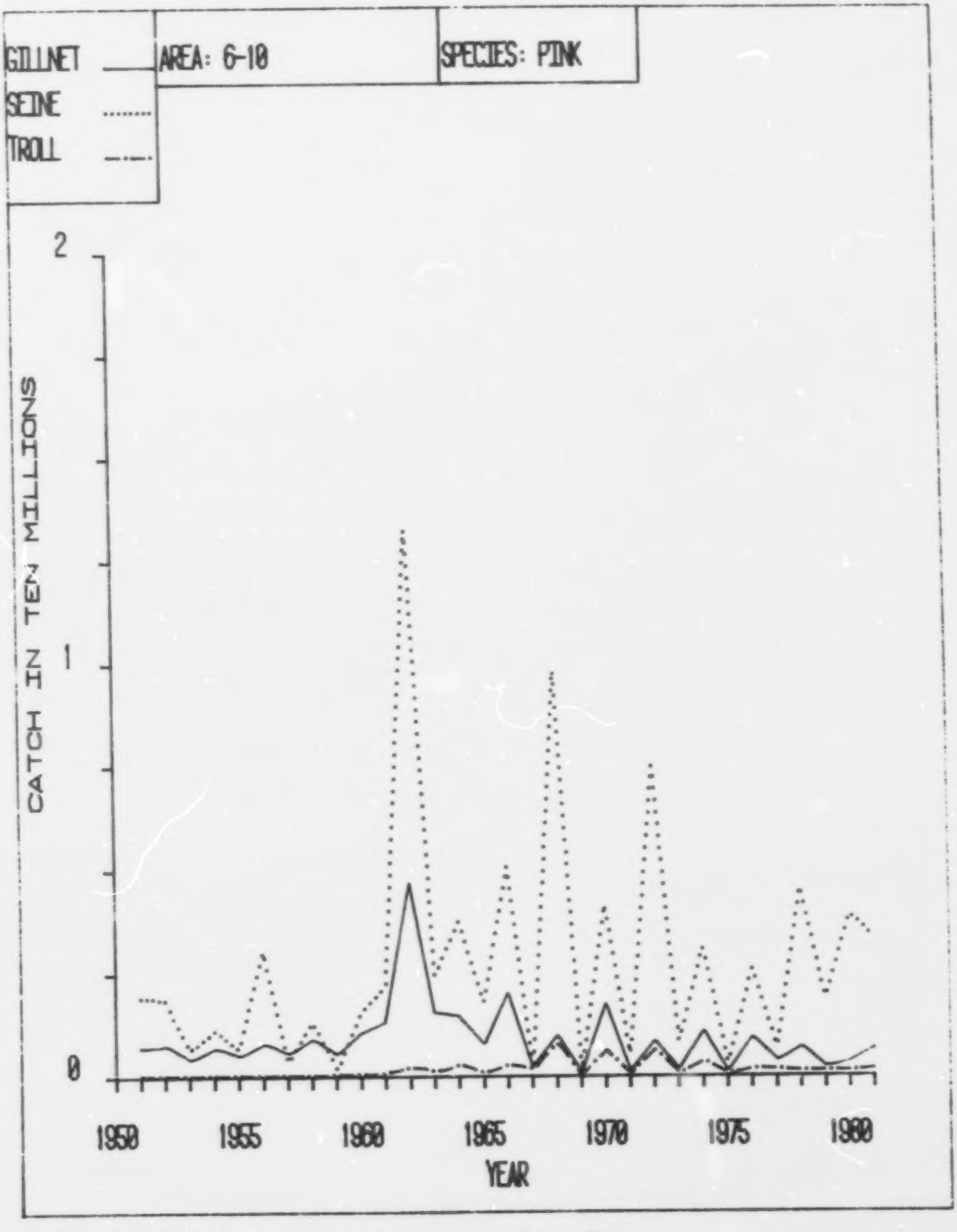

Fig. 43. Catch by gear of Central Coast pink salmon.

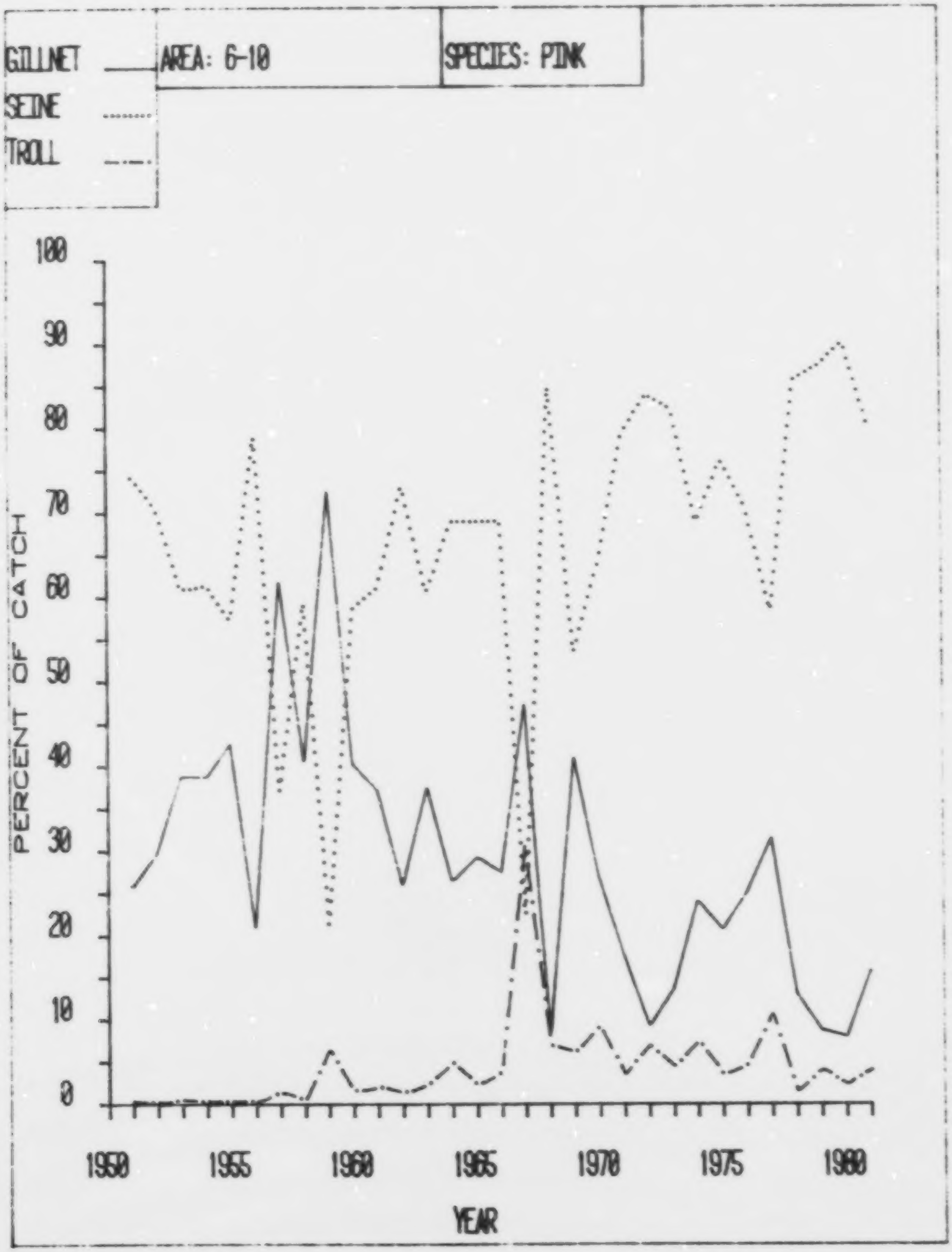

Fig. 44. Percent of total catch by gear of Central Coast pink salmon.

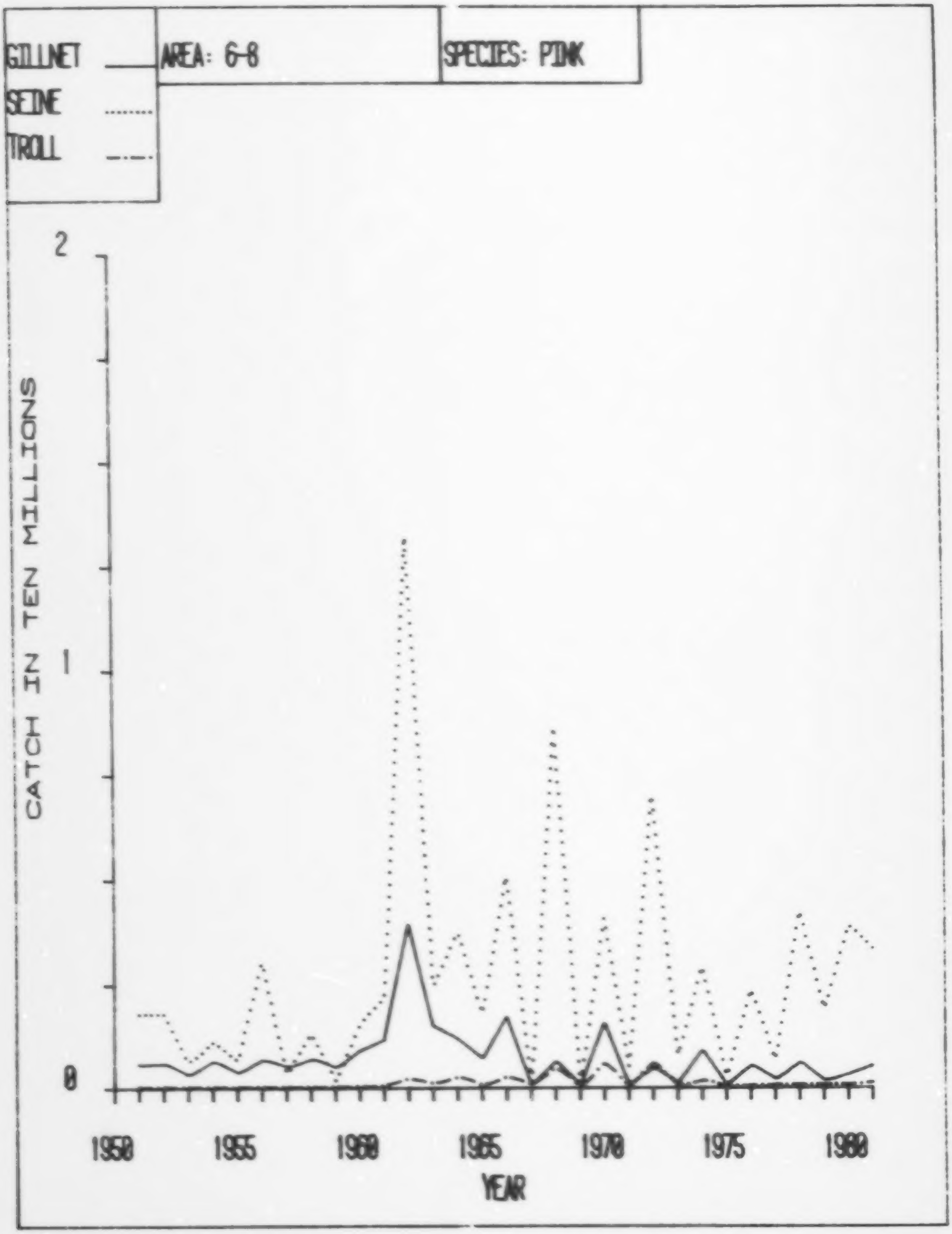

Fig. 45. Catch gear of pink salmon in Statistical Areas 6-8.

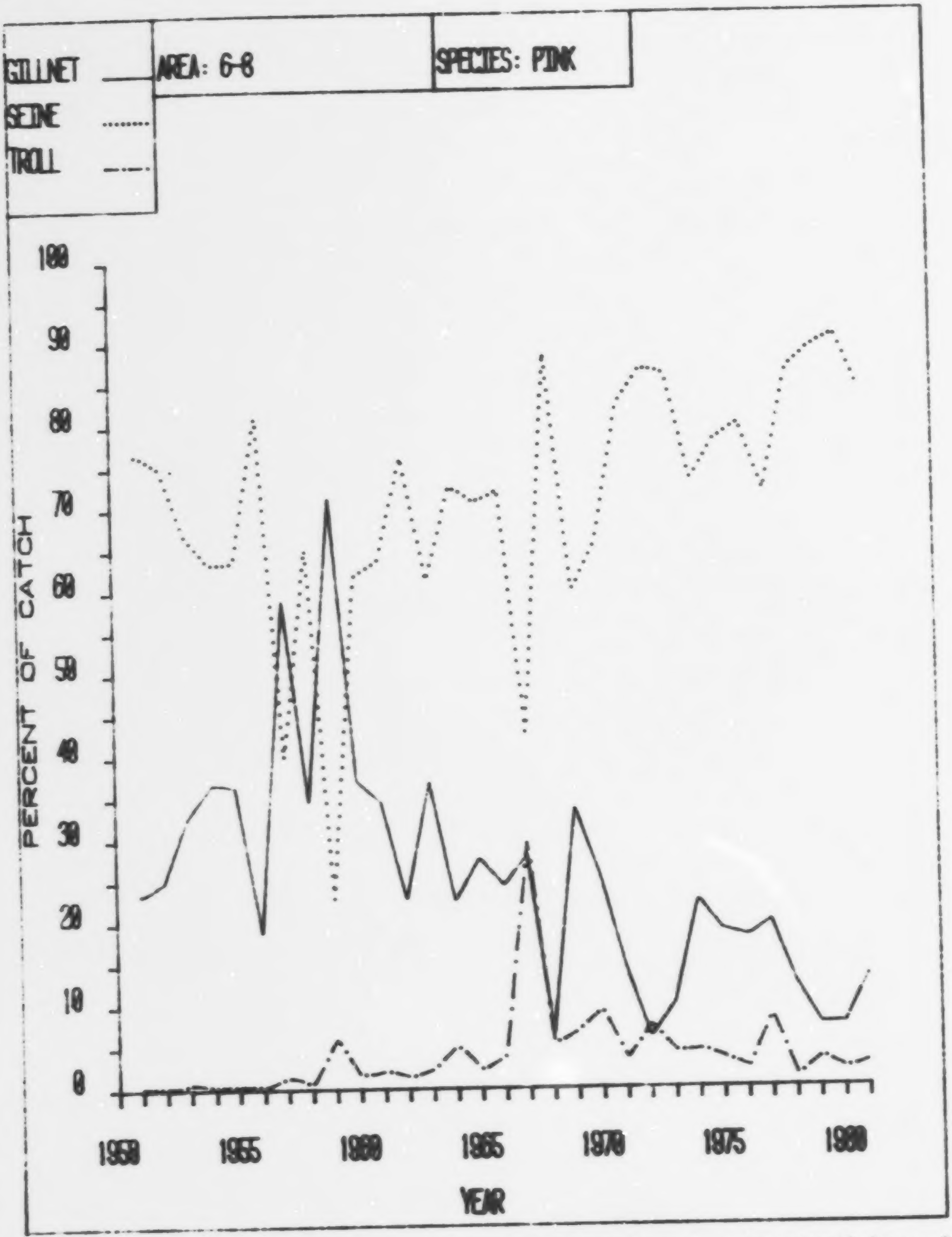

Fig. 46. Percent of total catch by gear of pink salmon in Statistical Areas 6-8.

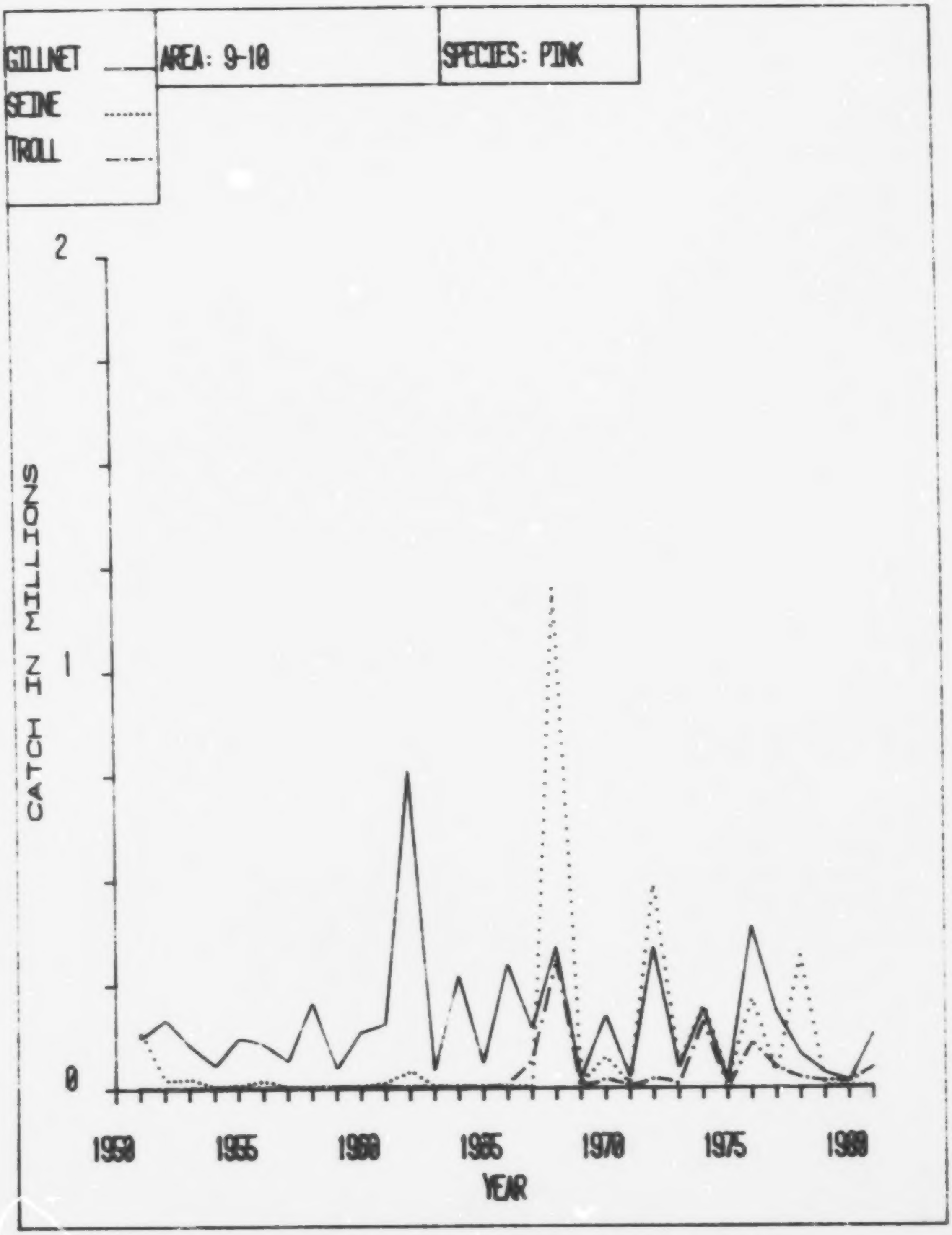

Fig. 47. Catch by gear of pink salmon in Statistical Areas 9-10.

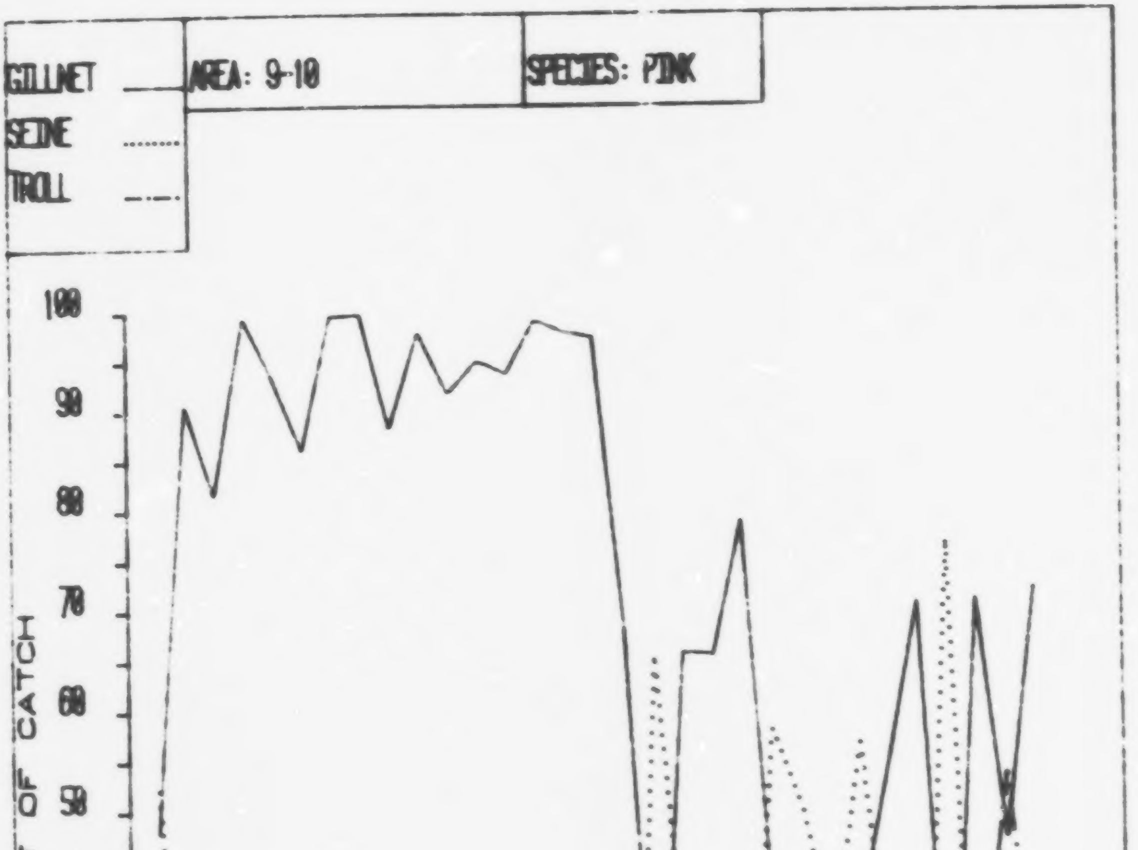

Fig. 48. Percent of total catch by gear of pink salmon in Statistical Areas 9-10.

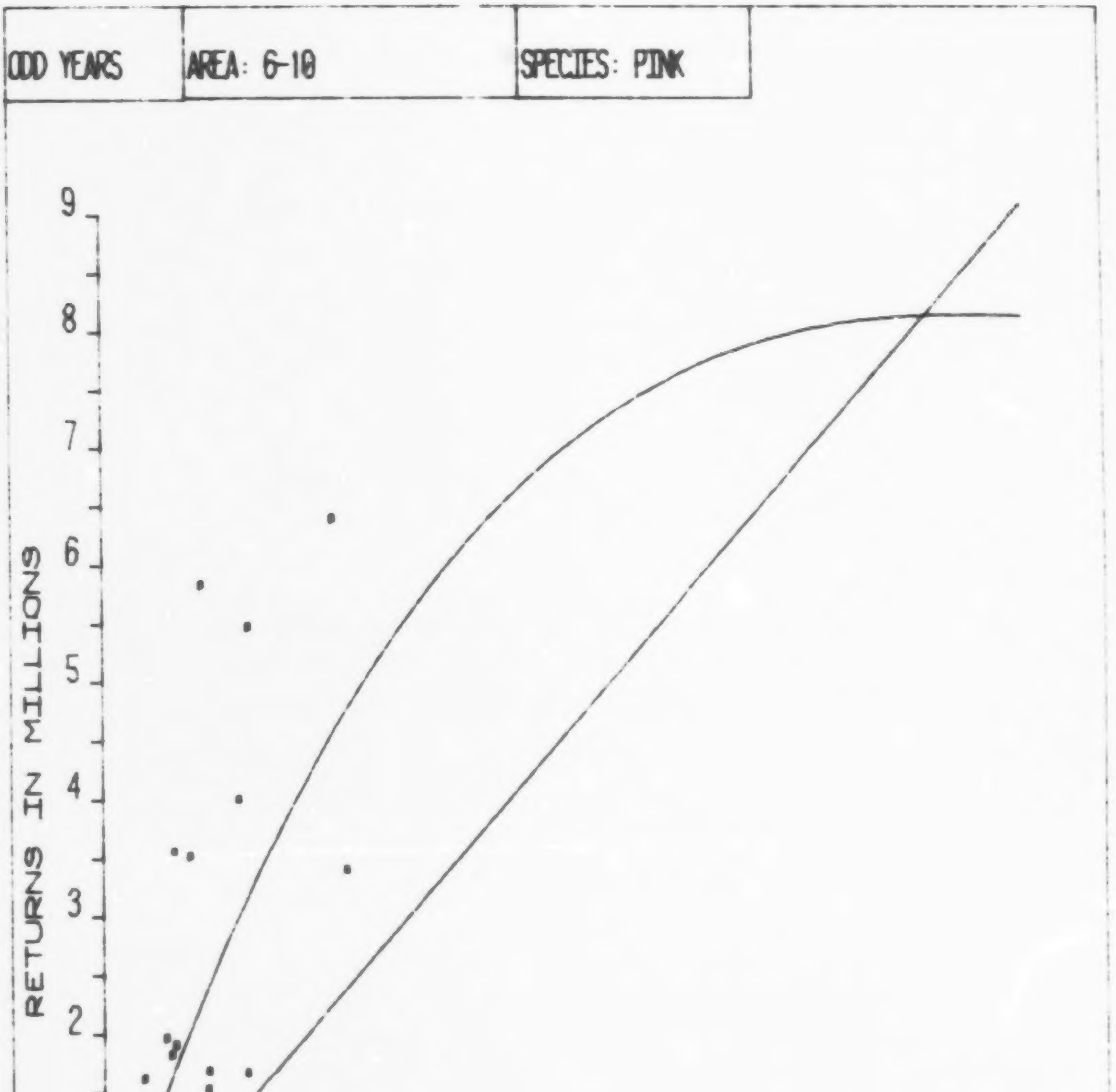

Fig. 49. Stock and recruitment relation for odd-numbered broodyears of Central Coast pink salmon, 1949-1979.

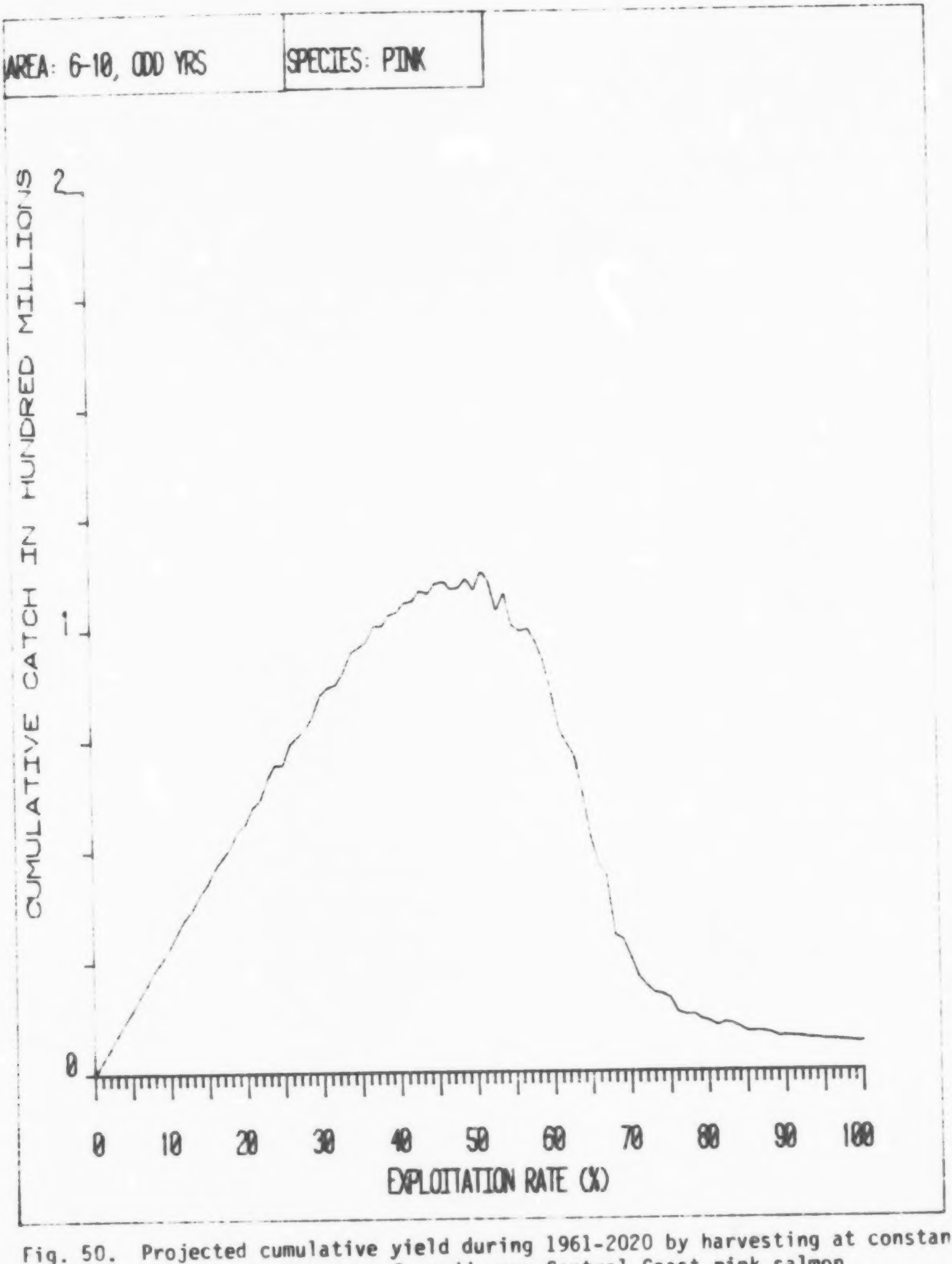

Fig. 50. Projected cumulative yield during 1961-2020 by harvesting at constant exploitation rate in each year for odd-year Central Coast pink salmon.

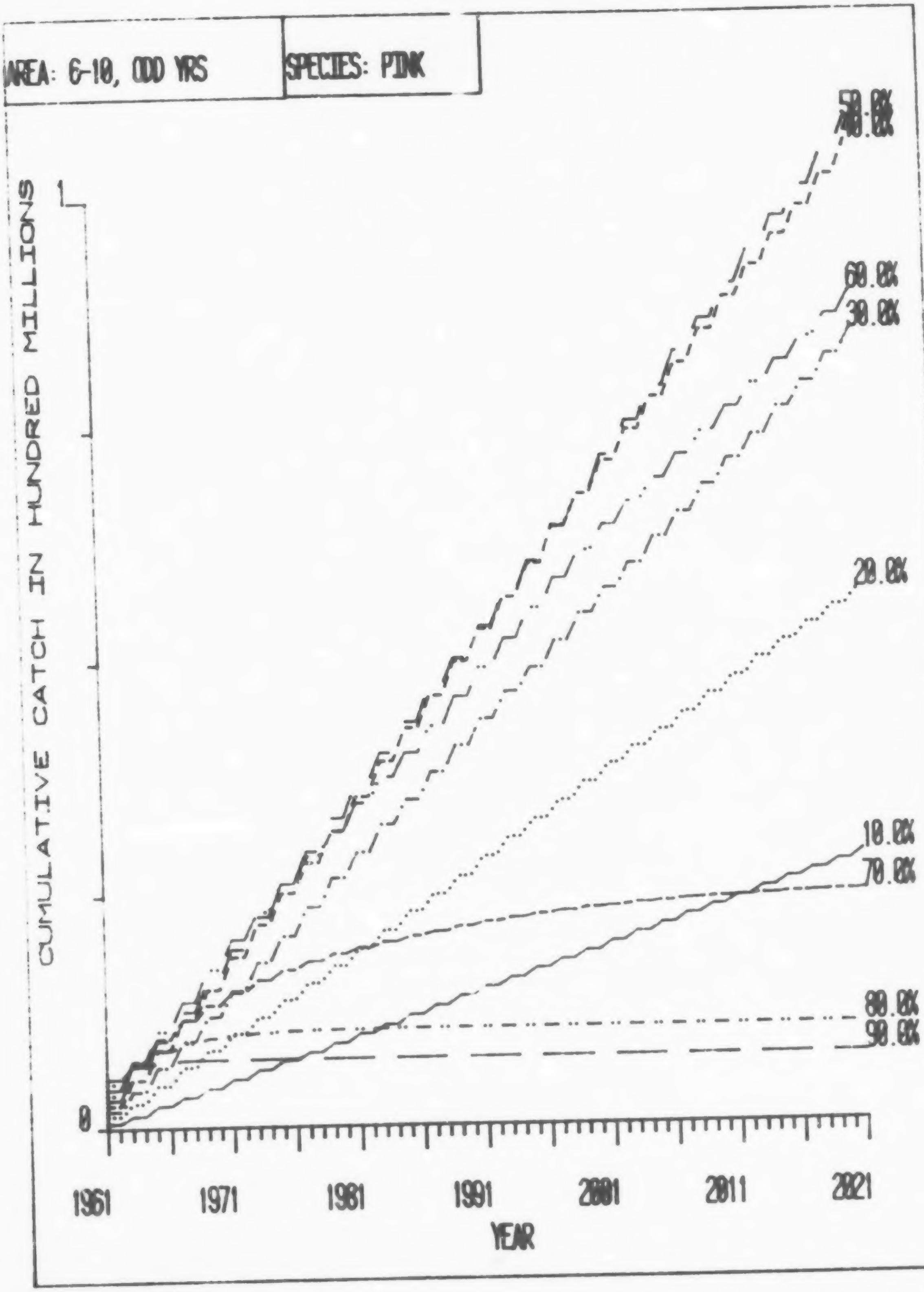

Fig. 51. Summary of yields under a 60-year projection of exploitation rates of 10-90% for odd-year Central Coast pink salmon.

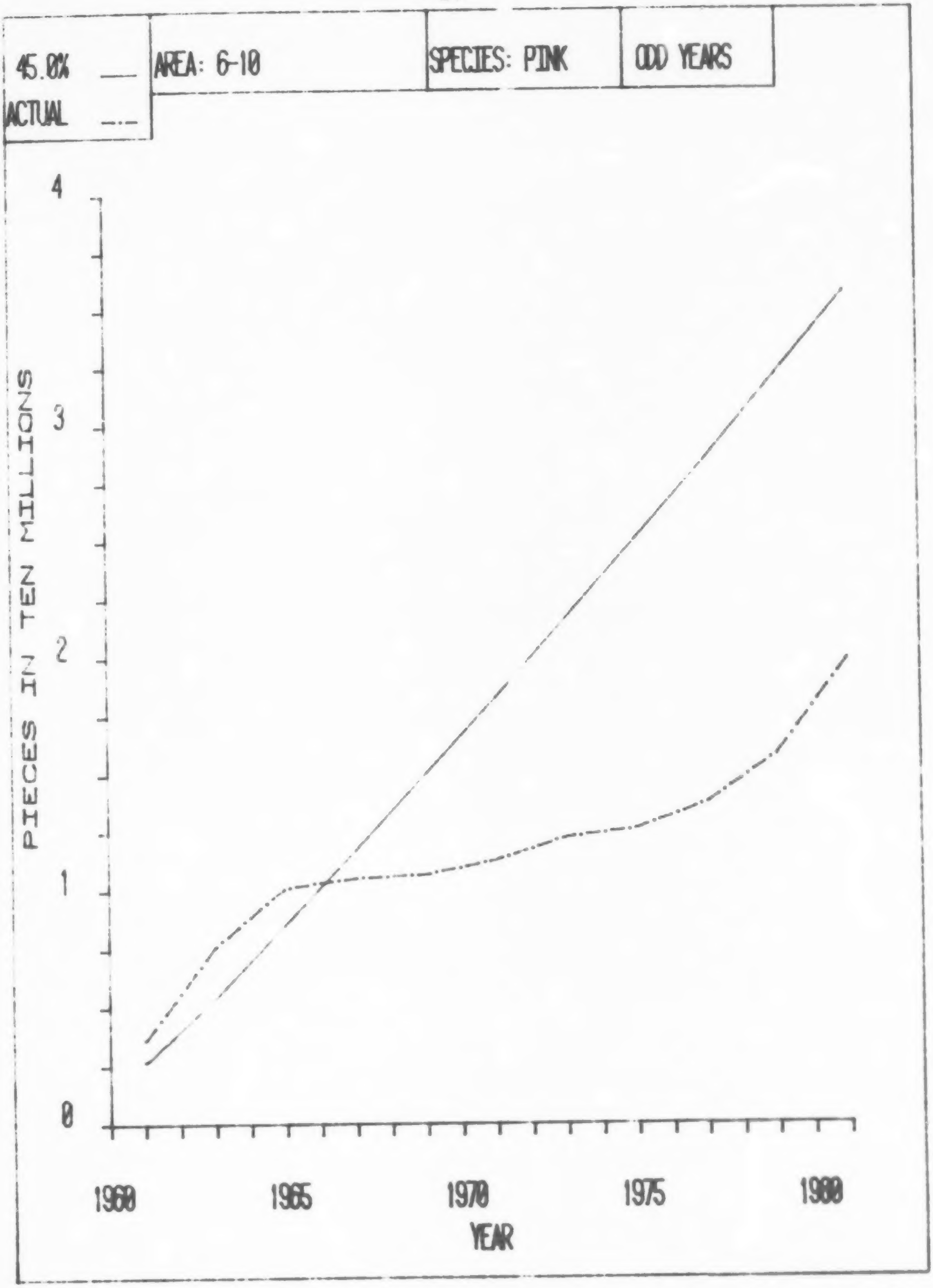

Fig. 52. Actual cumulative catch and projected cumulative catch under policy of 45% annual exploitation rate during 1961-1981 of odd-year Central Coast pink salmon.

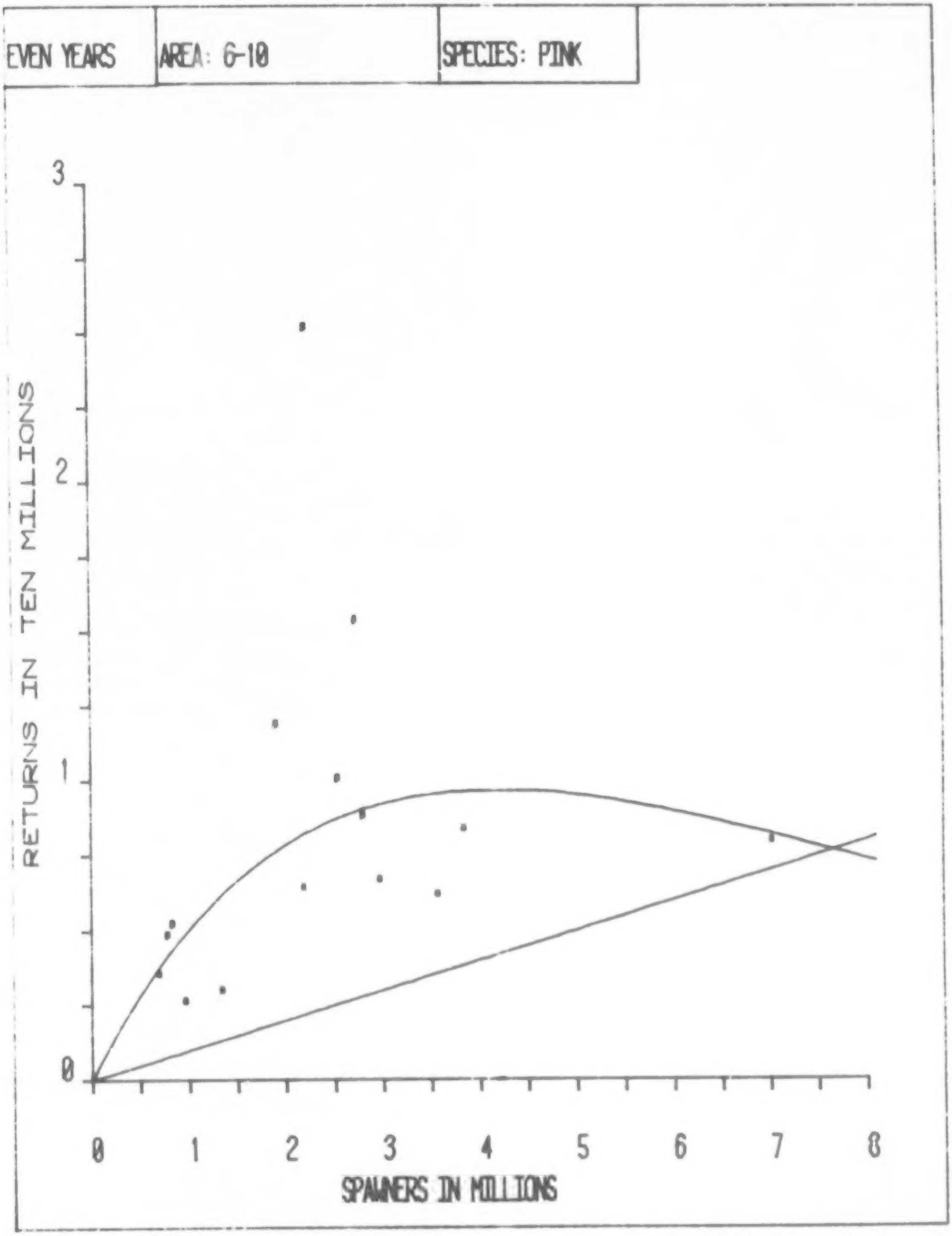

Fig. 53. Stock and recruitment relation for even-numbered broodyears of Central Coast pink salmon, 1950-1978.

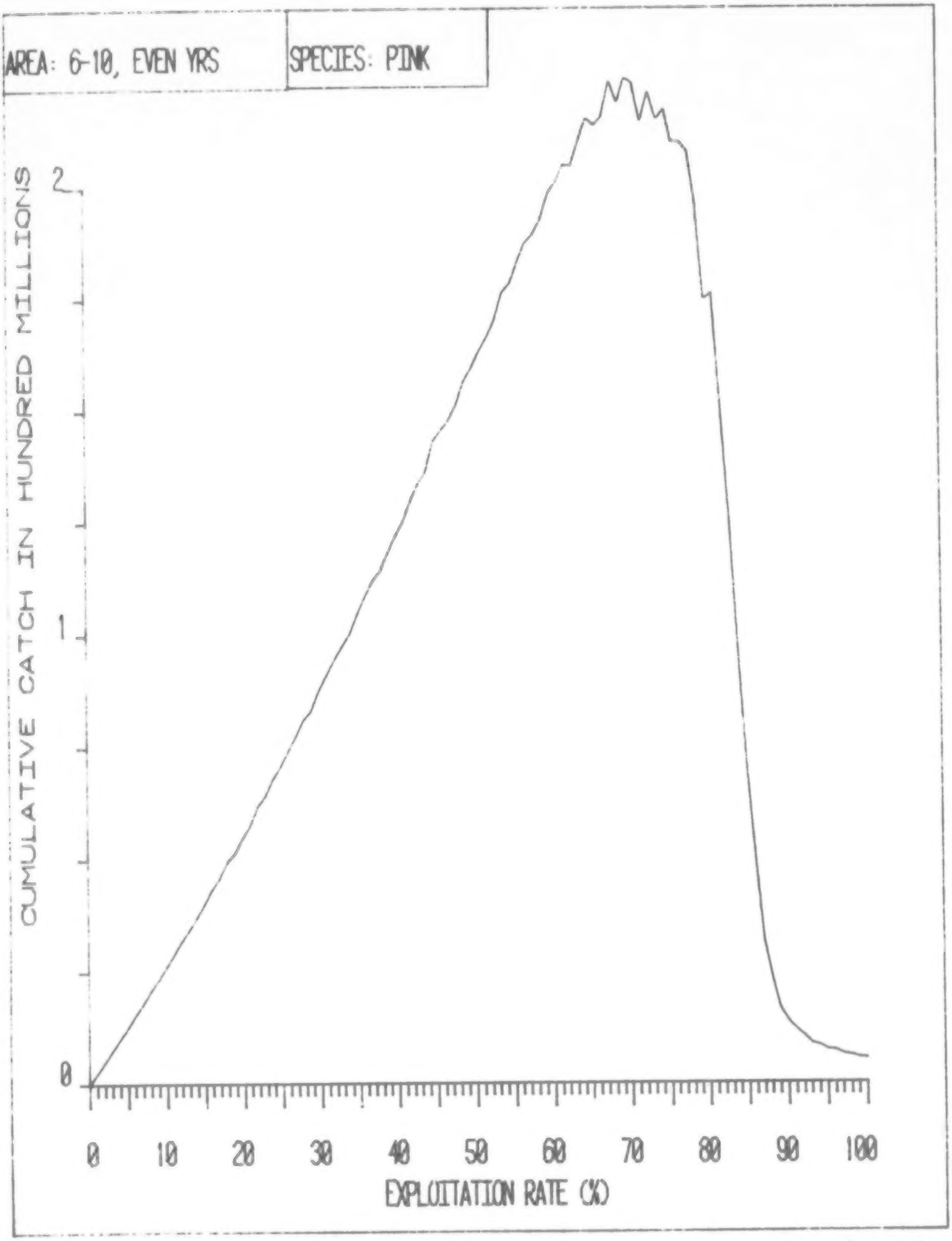

Fig. 54. Projected cumulative yield during 1960-2020 by harvesting of constant exploitation rate in each year for even-year Central Coast pink salmon.

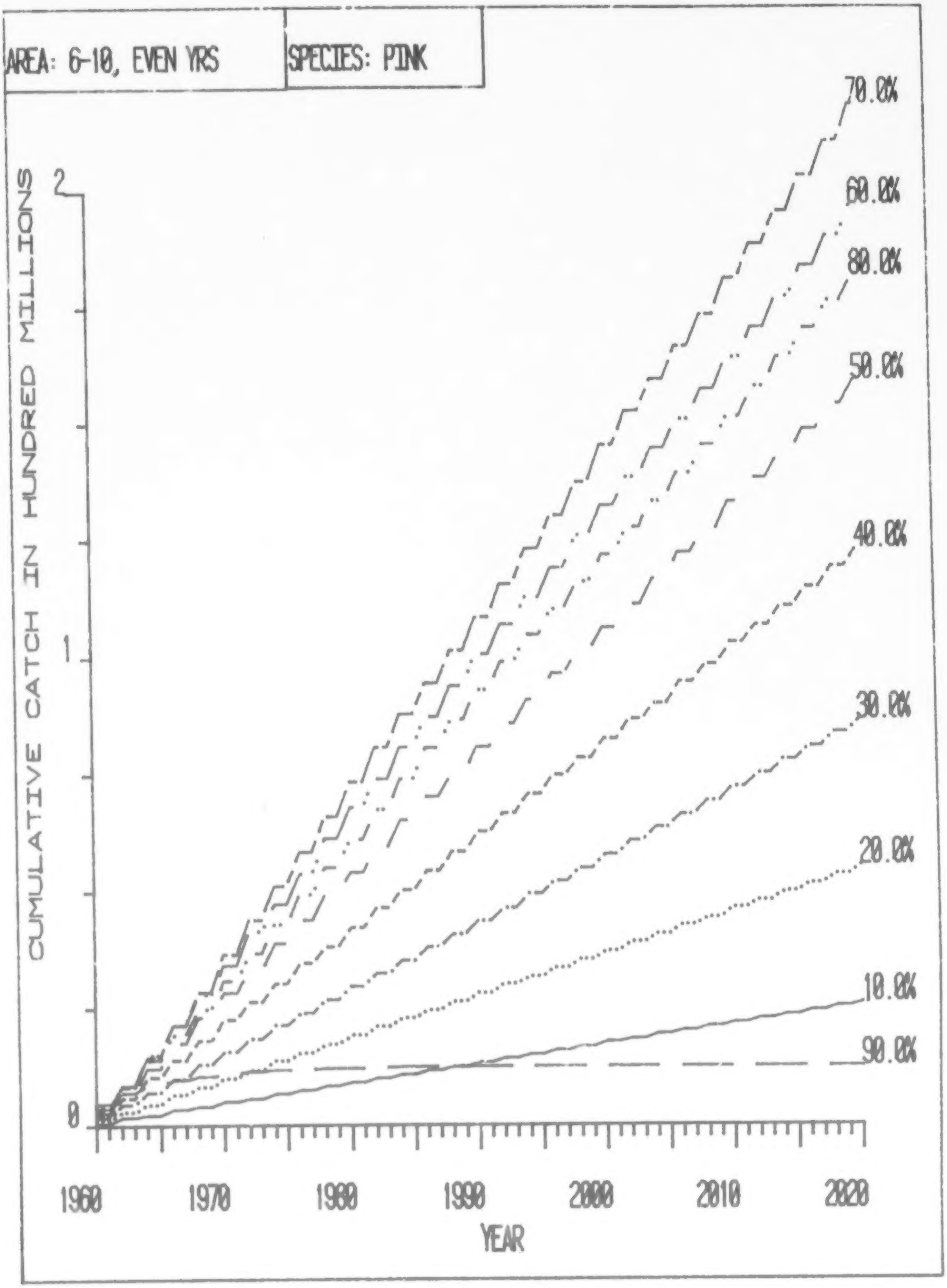

Fig. 55. Summary of yields under a 60-year projection of exploitation rates of 10-90% for even-year Central Coast pink salmon.

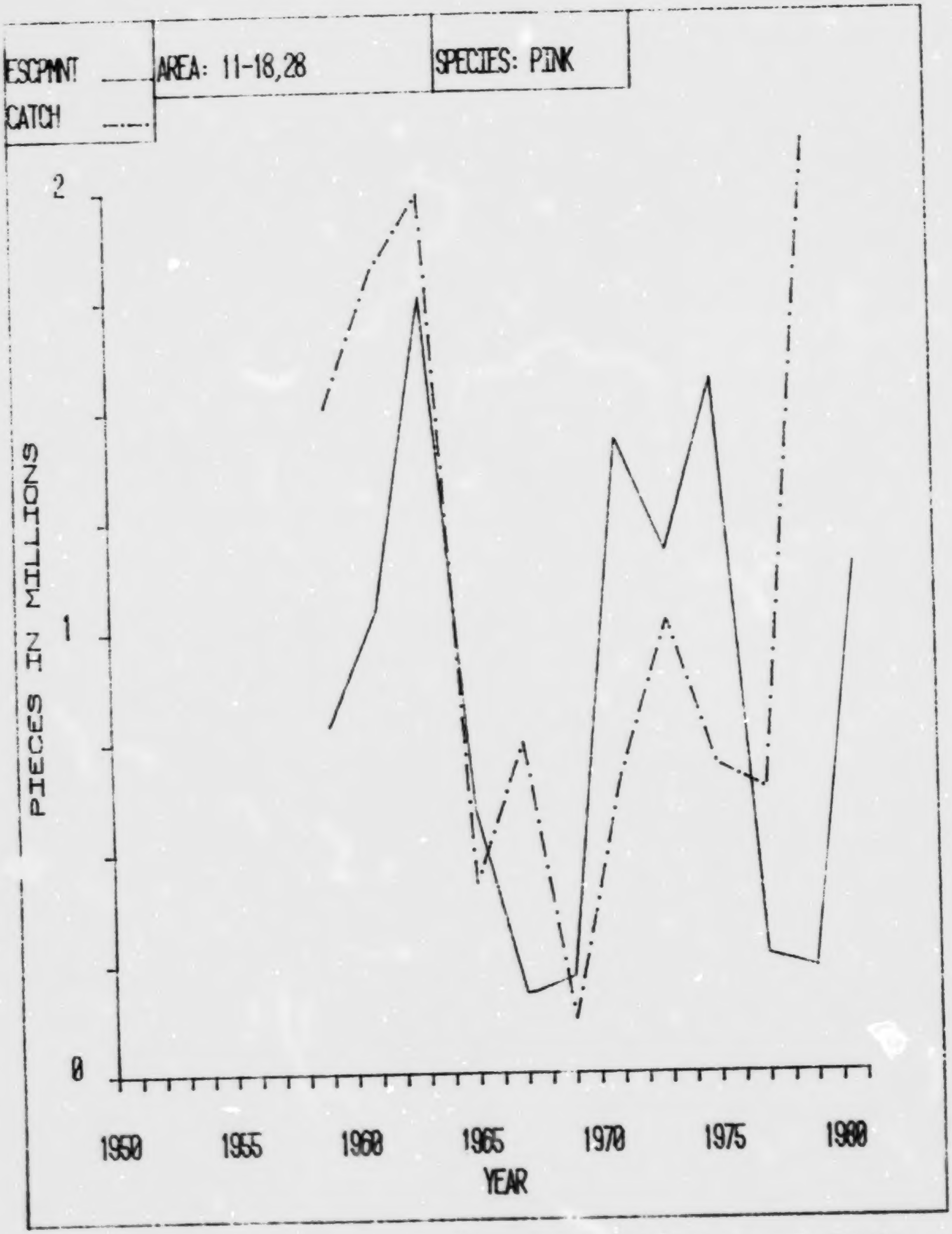

Fig. 56. Catch and escapement of odd-year Johnstone Strait-Georgia Strait pink salmon.

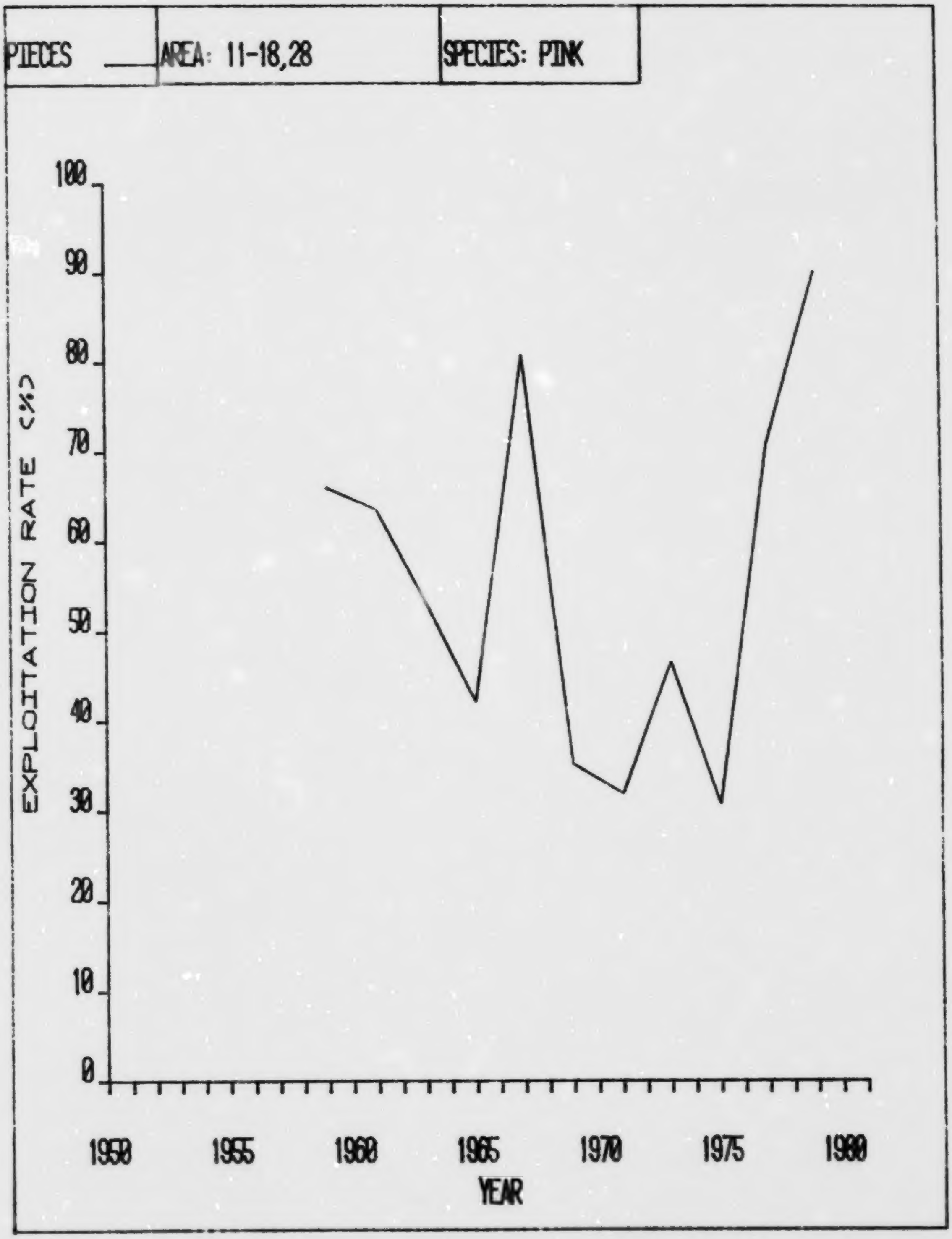

Fig. 57. Exploitation rate of odd-year Johnstone Strait-Georgia Strait pink salmon.

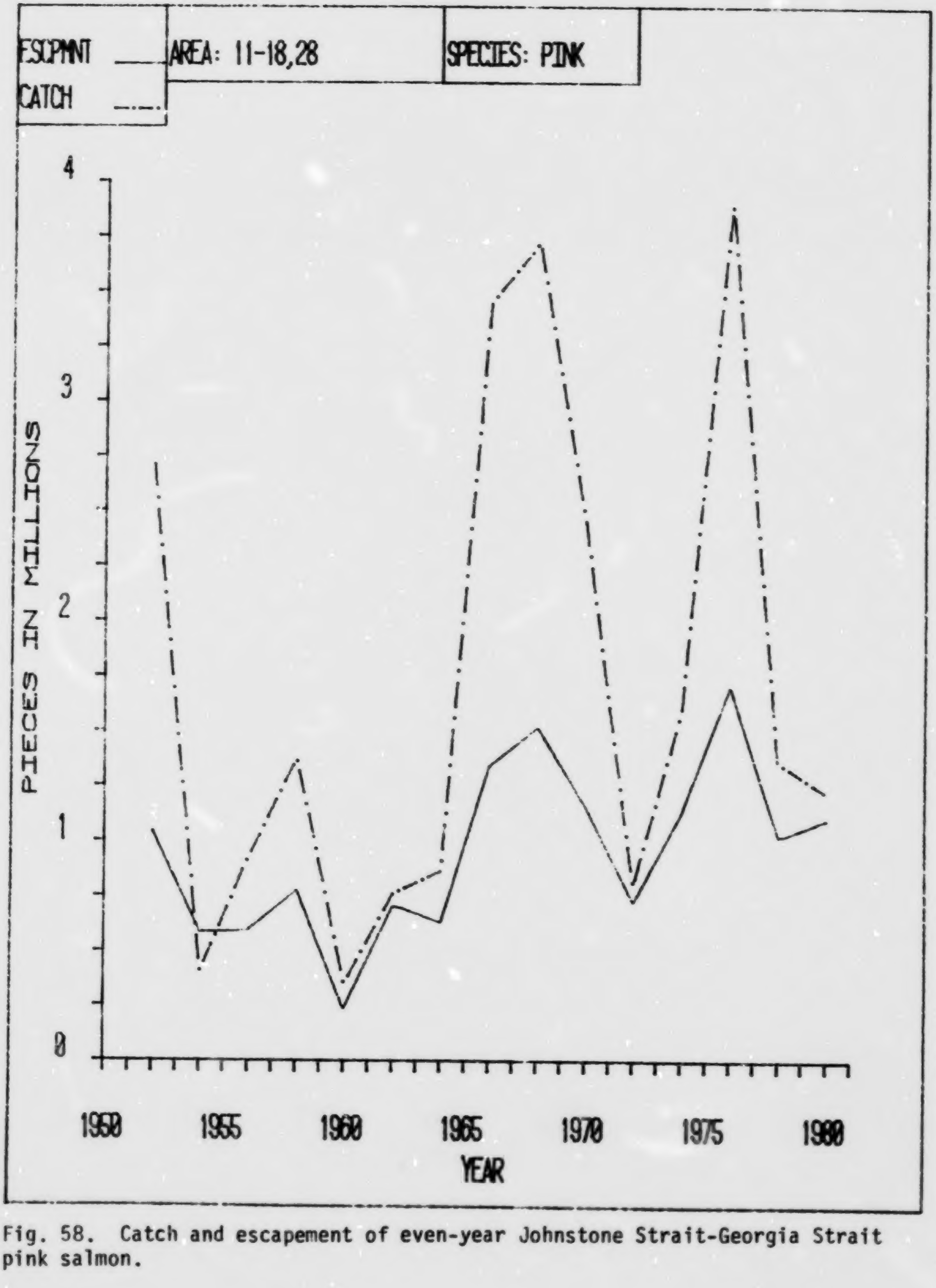

Fig. 58. Catch and escapement of even-year Johnstone Strait-Georgia Strait pink salmon.

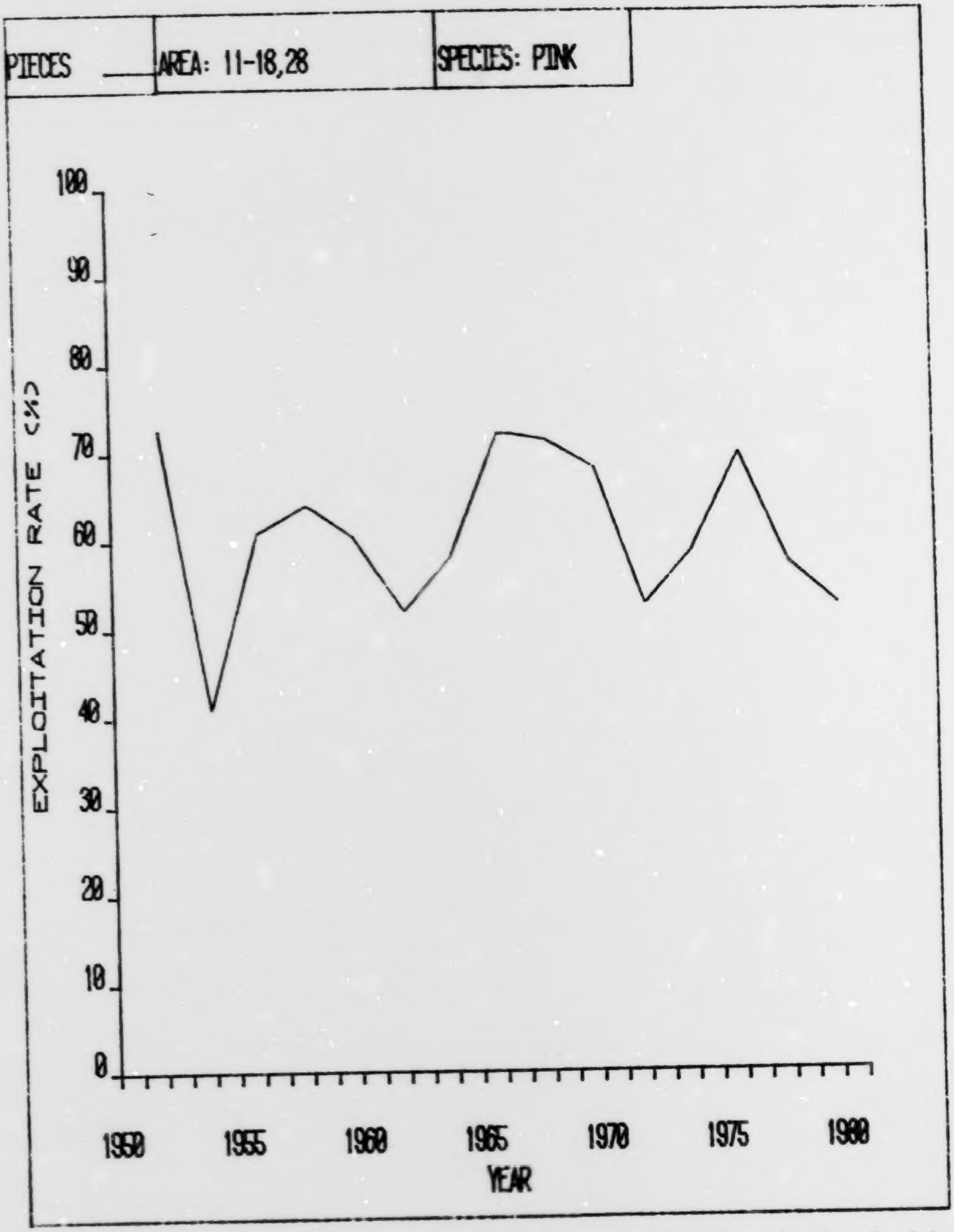

Fig. 59. Exploitation rate of even-year Johnstone Strait-Georgia Strait pink salmon.

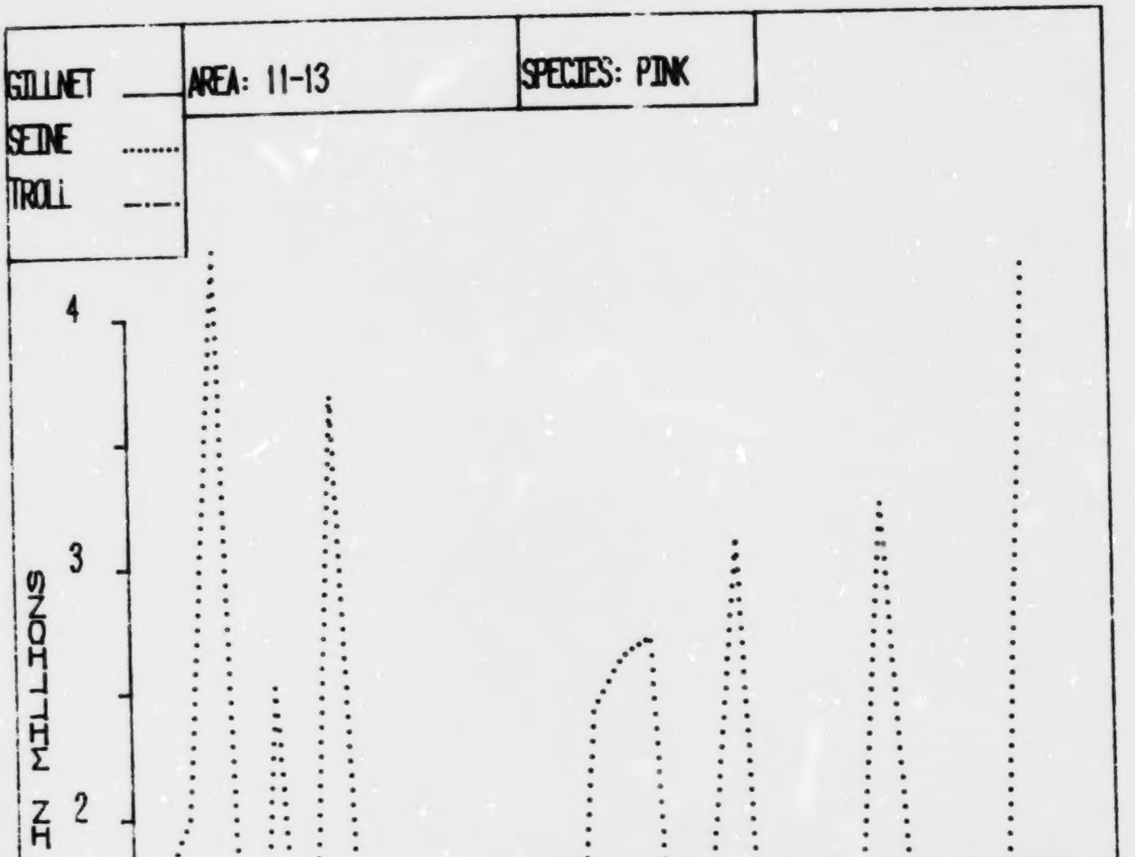

Fig. 60. Catch by gear of pink salmon in Johnstone Strait.

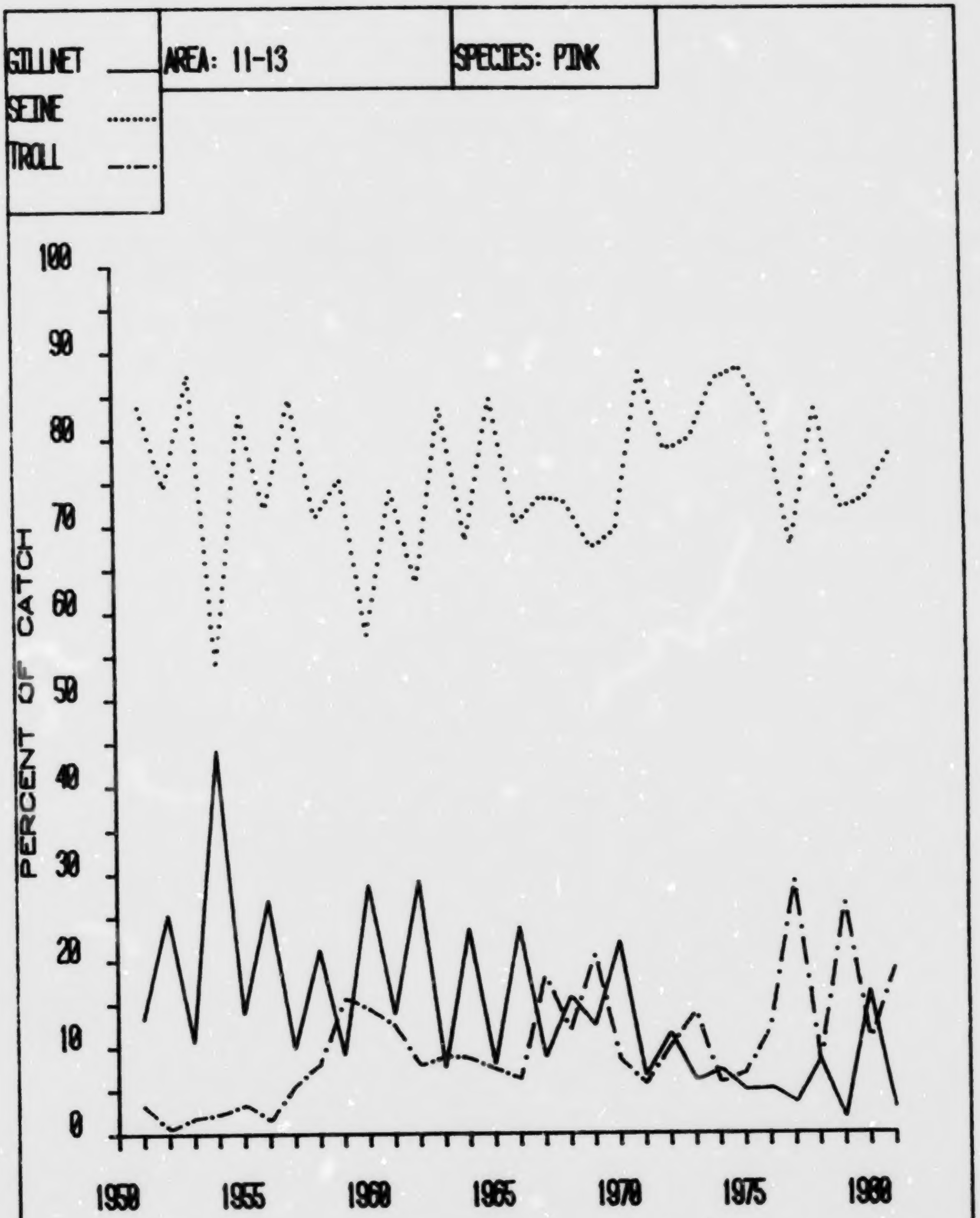

Fig. 61. Percent of total catch by gear of pink salmon in Johnstone Strait.

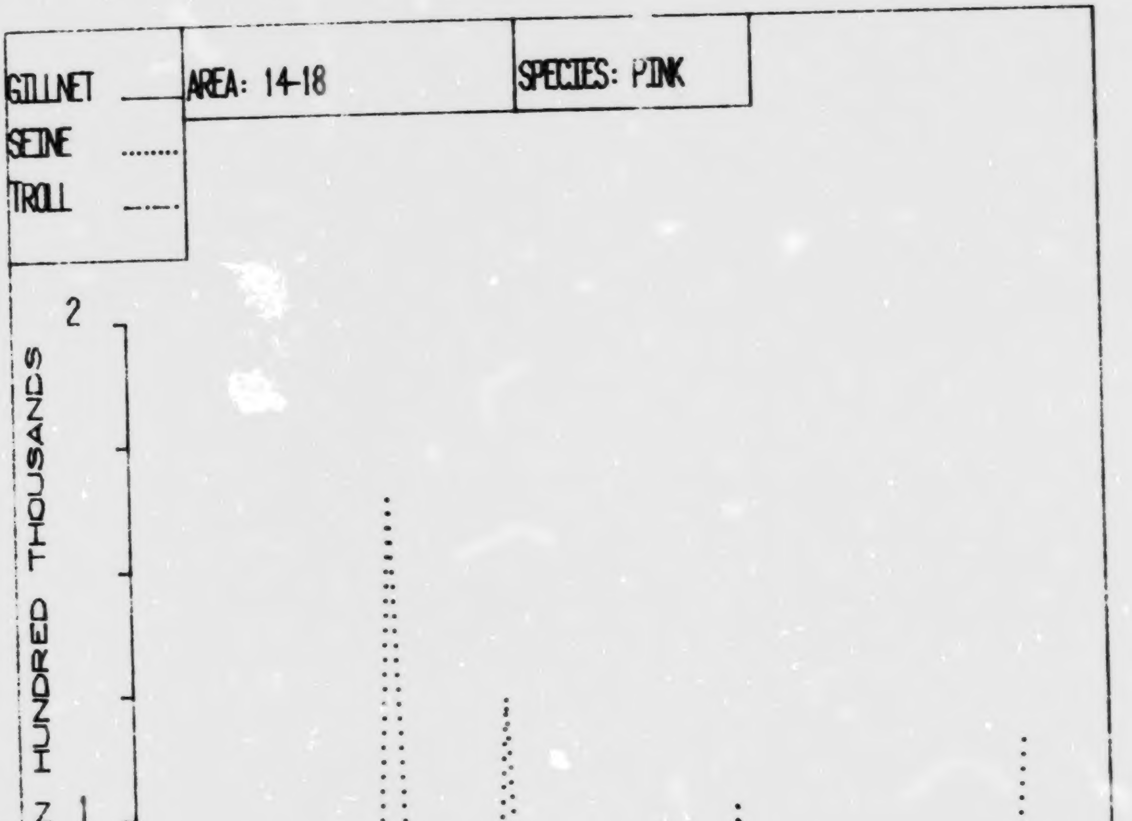

Fig. 62. Catch by gear of pink salmon in Georgia Strait.

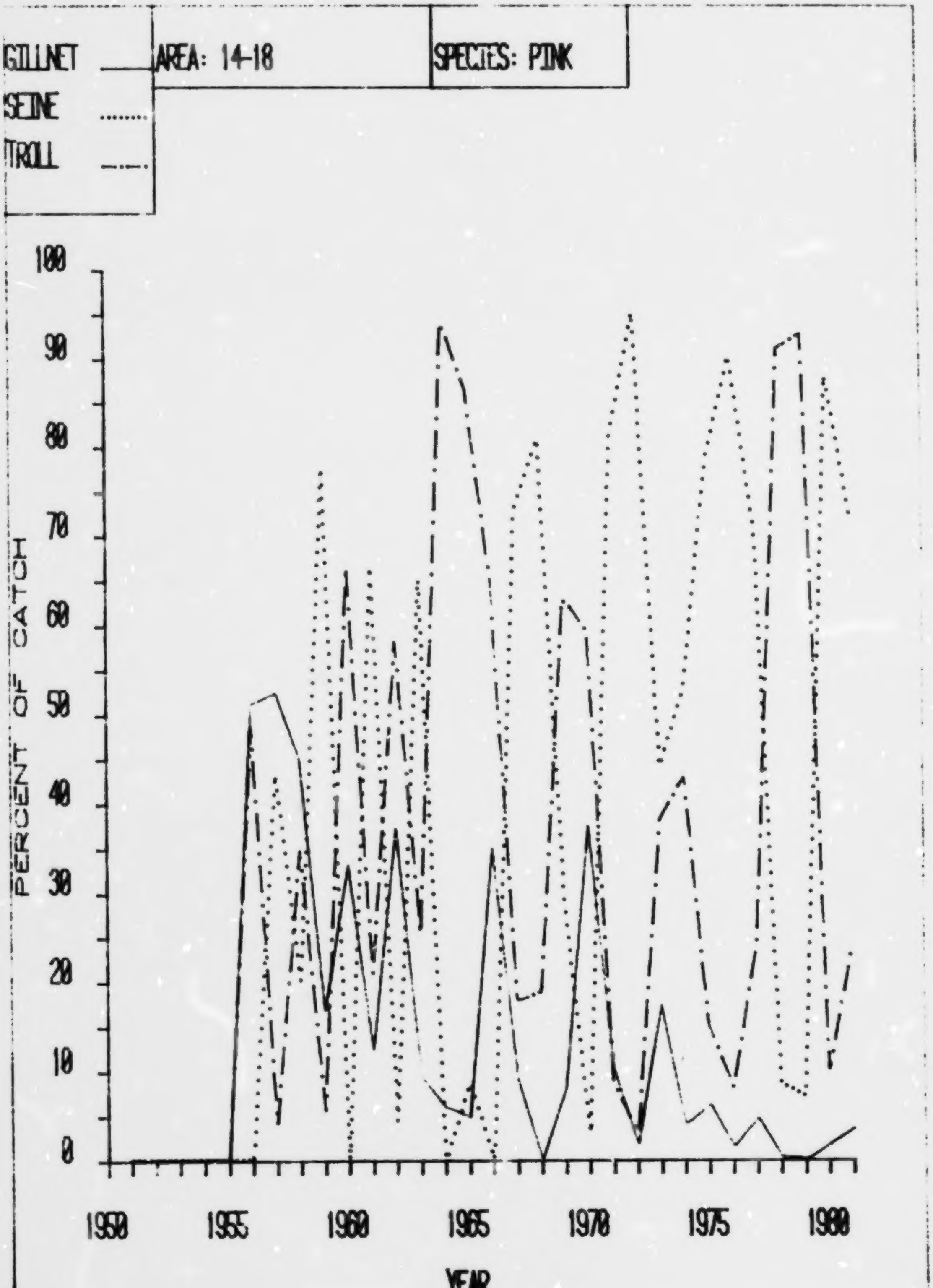

Fig. 63. Percent of total catch by gear of pink salmon in Georgia Strait.

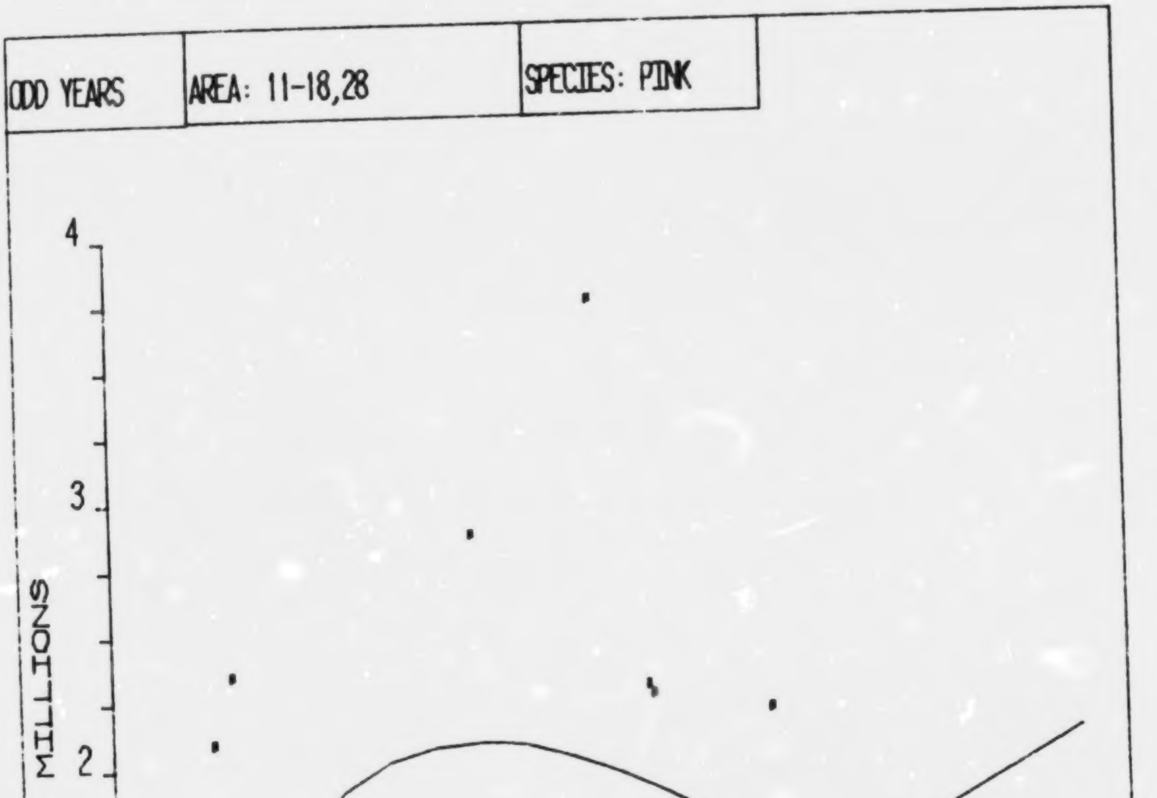

Fig. 64. Stock and recruitment relation for odd-year Johnstone Strait-Georgia Strait pink salmon, 1957-1977 broodyears.

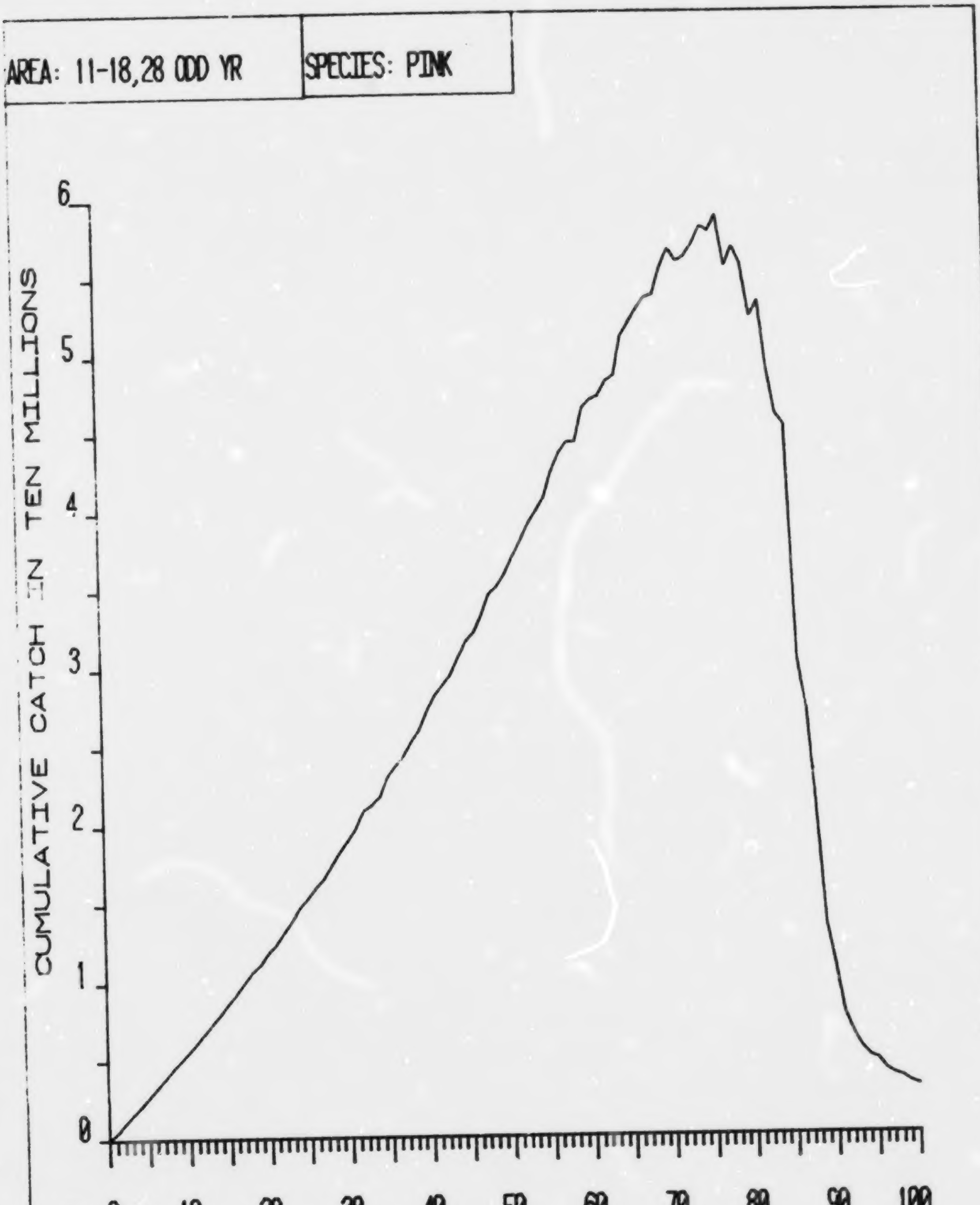

Fig. 65. Projected cumulative yield during 1961-2020 by harvesting at constant exploitation rate in each year for Johnstone Strait-Georgia Strait pink salmon.

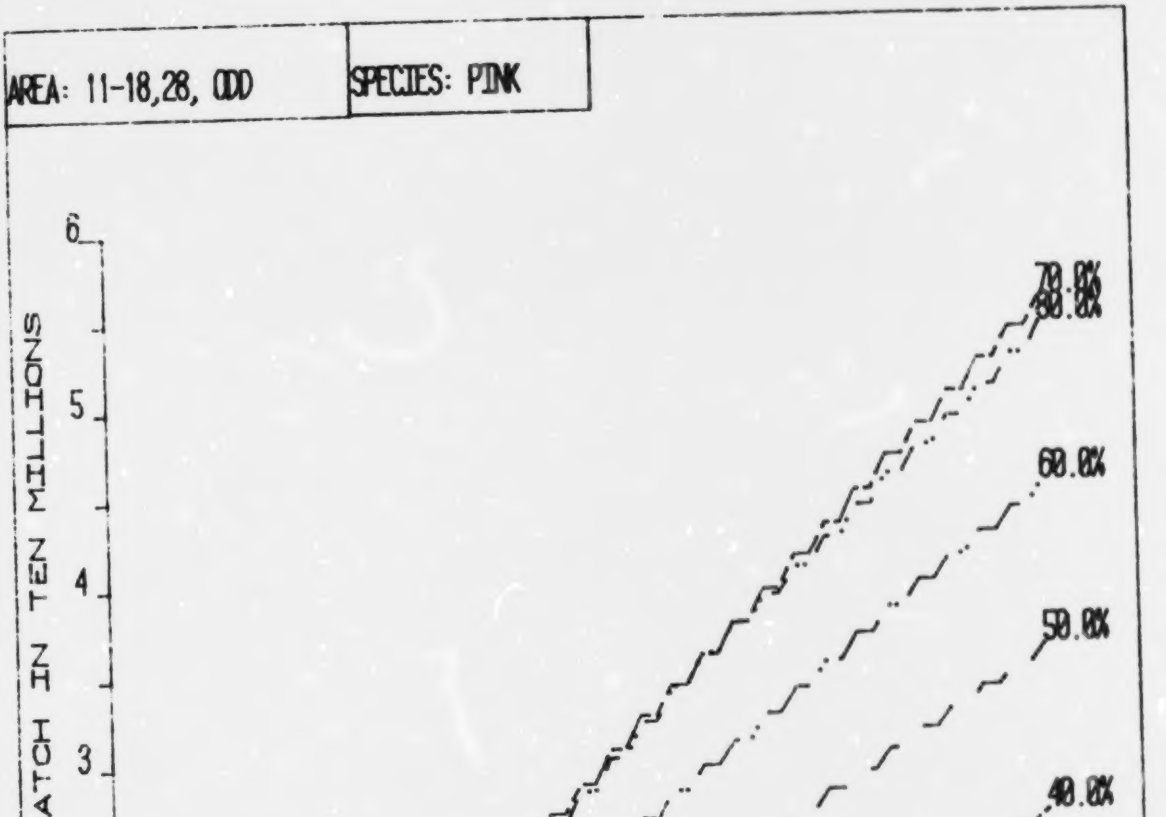

Fig. 66. Summary of yields under a 60-year projection of exploitation rates of 10-90% for Johnstone Strait-Georgia Strait pink salmon.

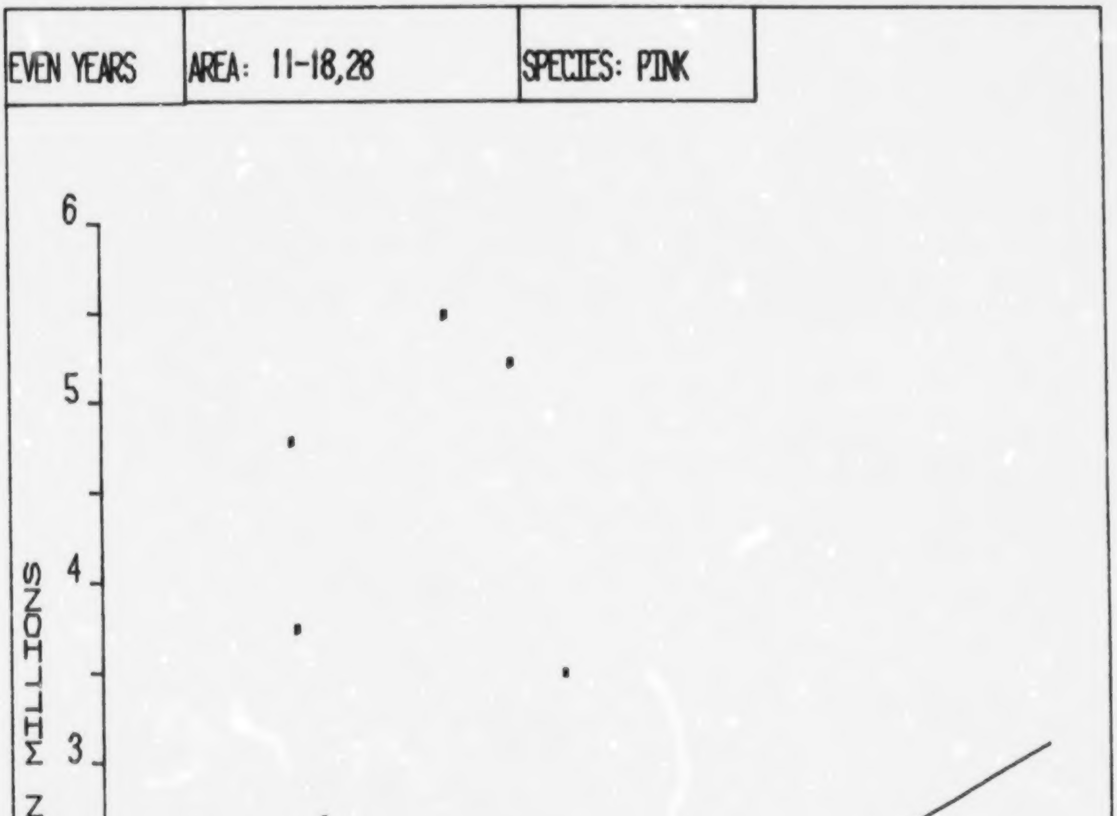

Fig. 67. Stock and recruitment relation for even-year Johnstone Strait-Georgia Strait pink salmon, 1950-1978 broodyears.

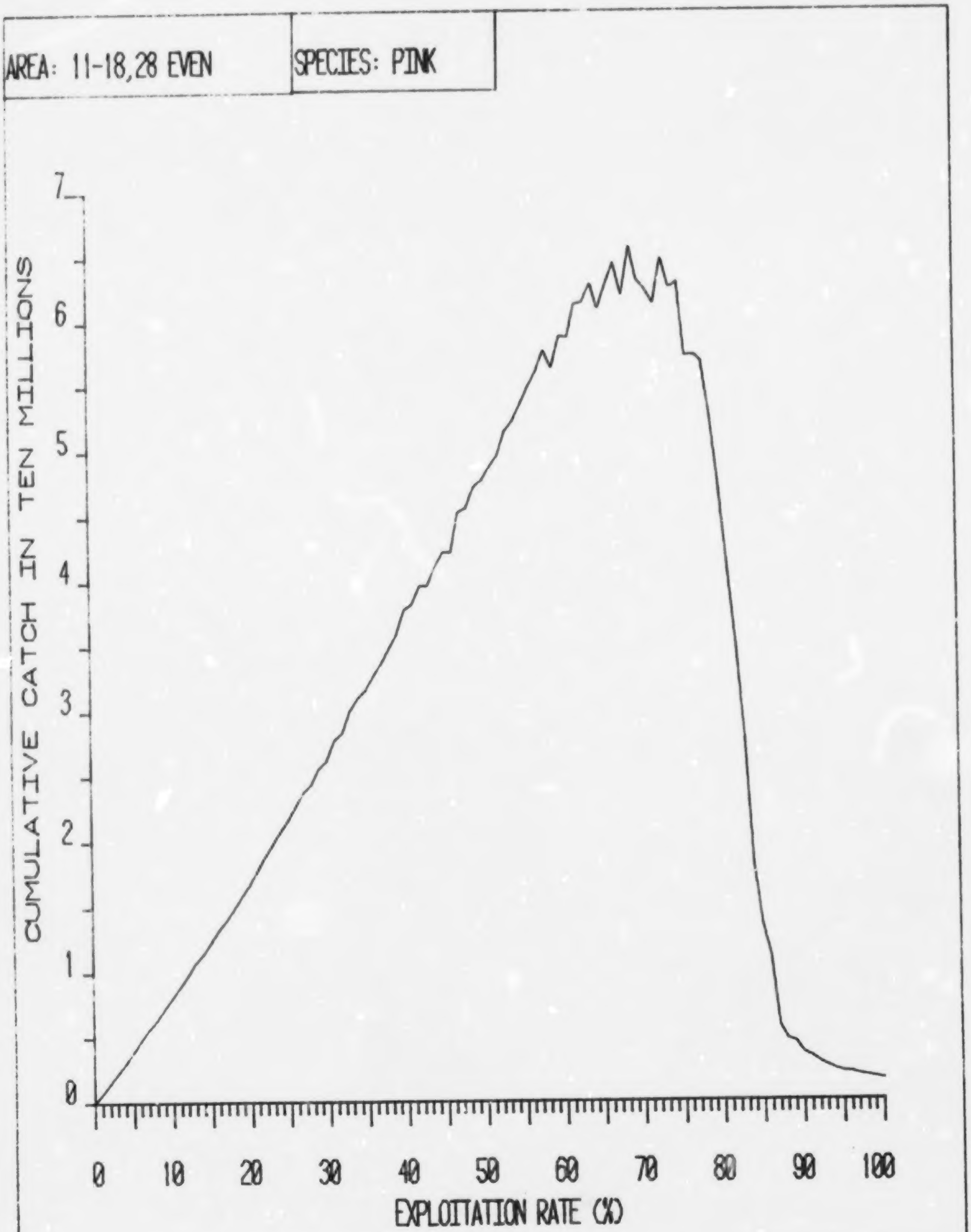

Fig. 68. Projected cumulative yield during 1960-2020 by harvesting at constant exploitation rate in each year for even-year Johnstone Strait-Georgia Strait pink salmon.

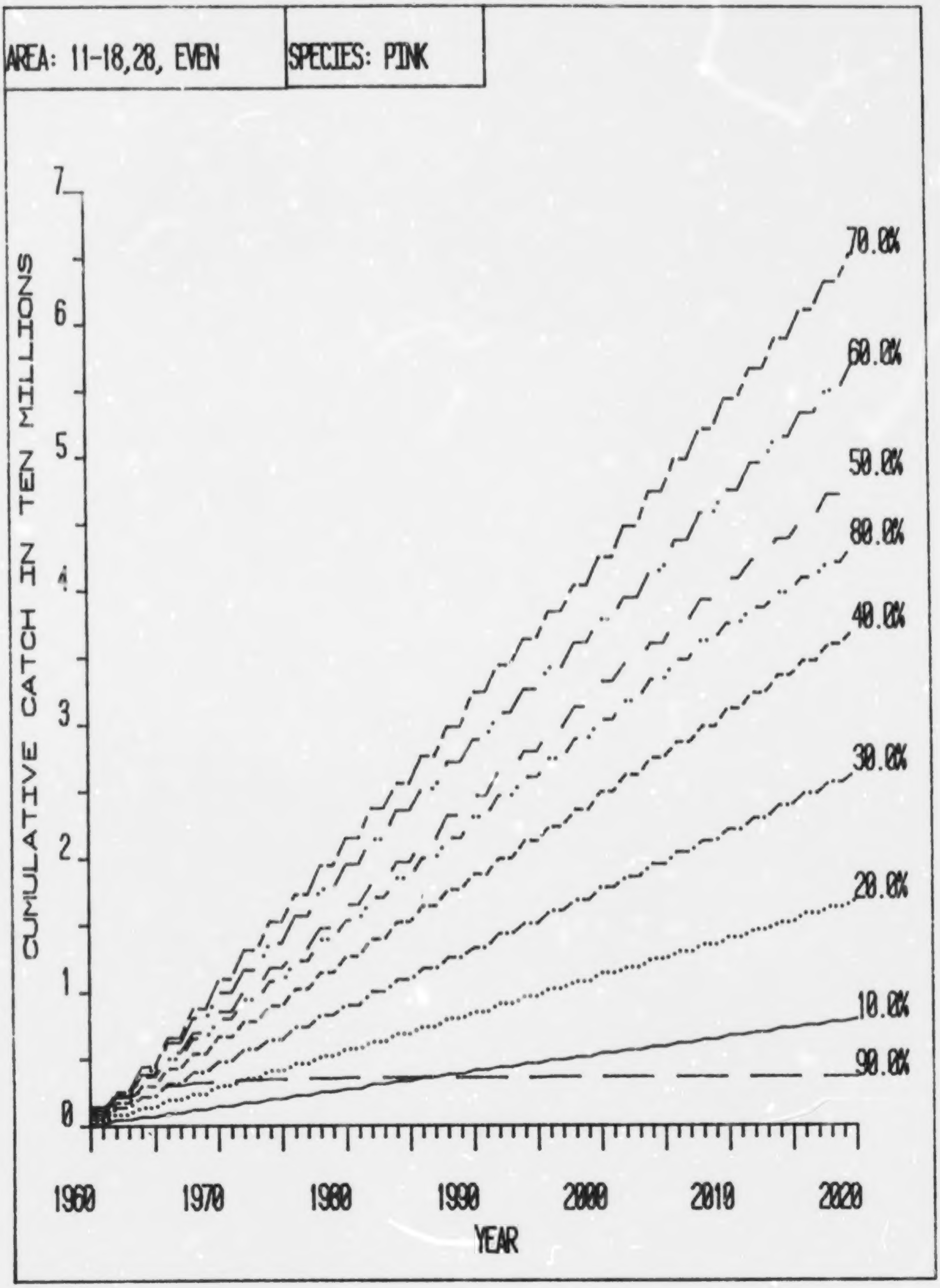

Fig. 69. Summary of yields under a 60-year projection of exploitation rates of 10-90% for even-year Johnstone Strait-Georgia Strait pink salmon.

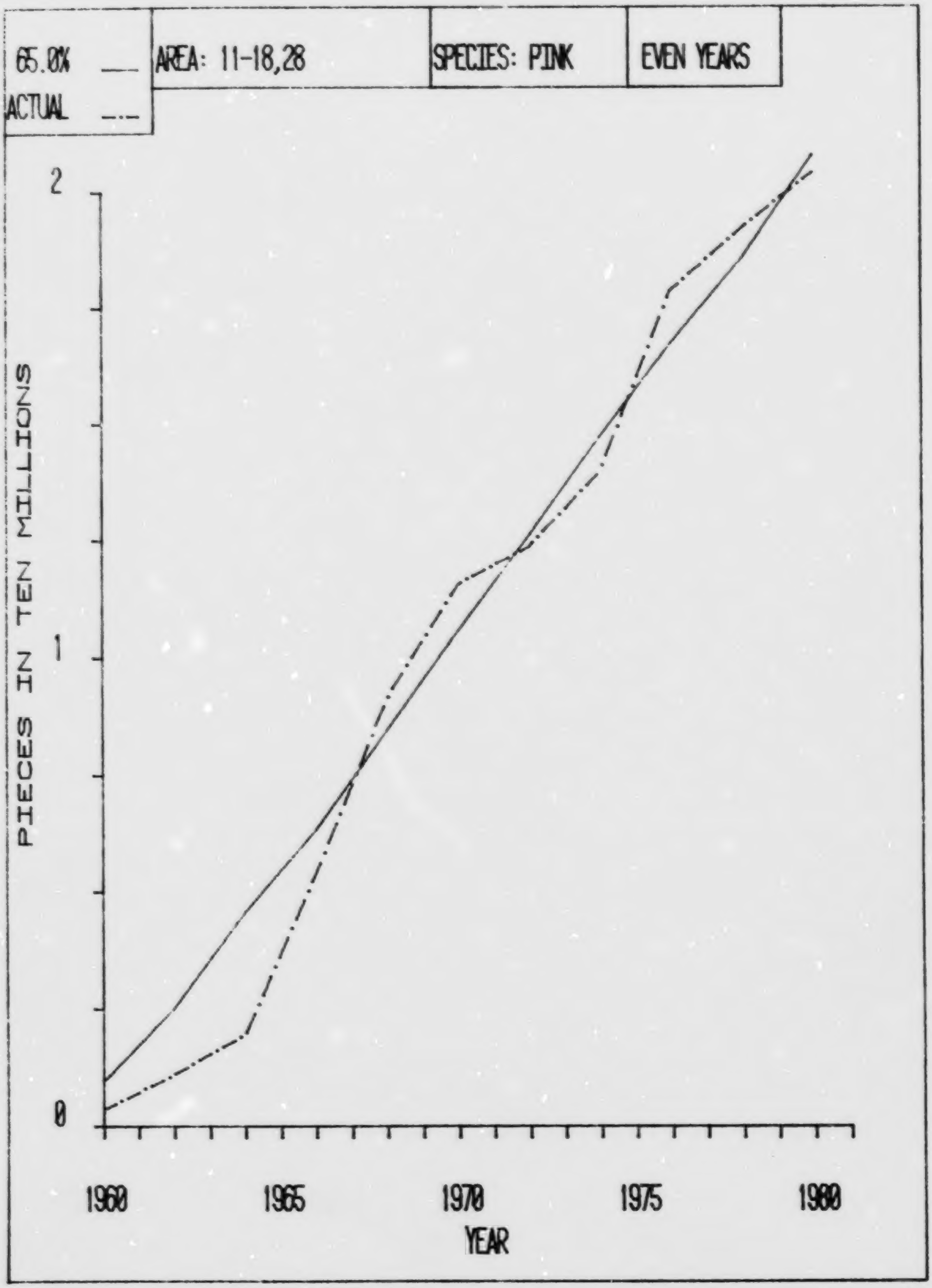

Fig. 70. Actual cumulative catch and projected cumulative rate during 1960-1980 of even-year Johnstone Strait-Georgia Strait pink salmon.

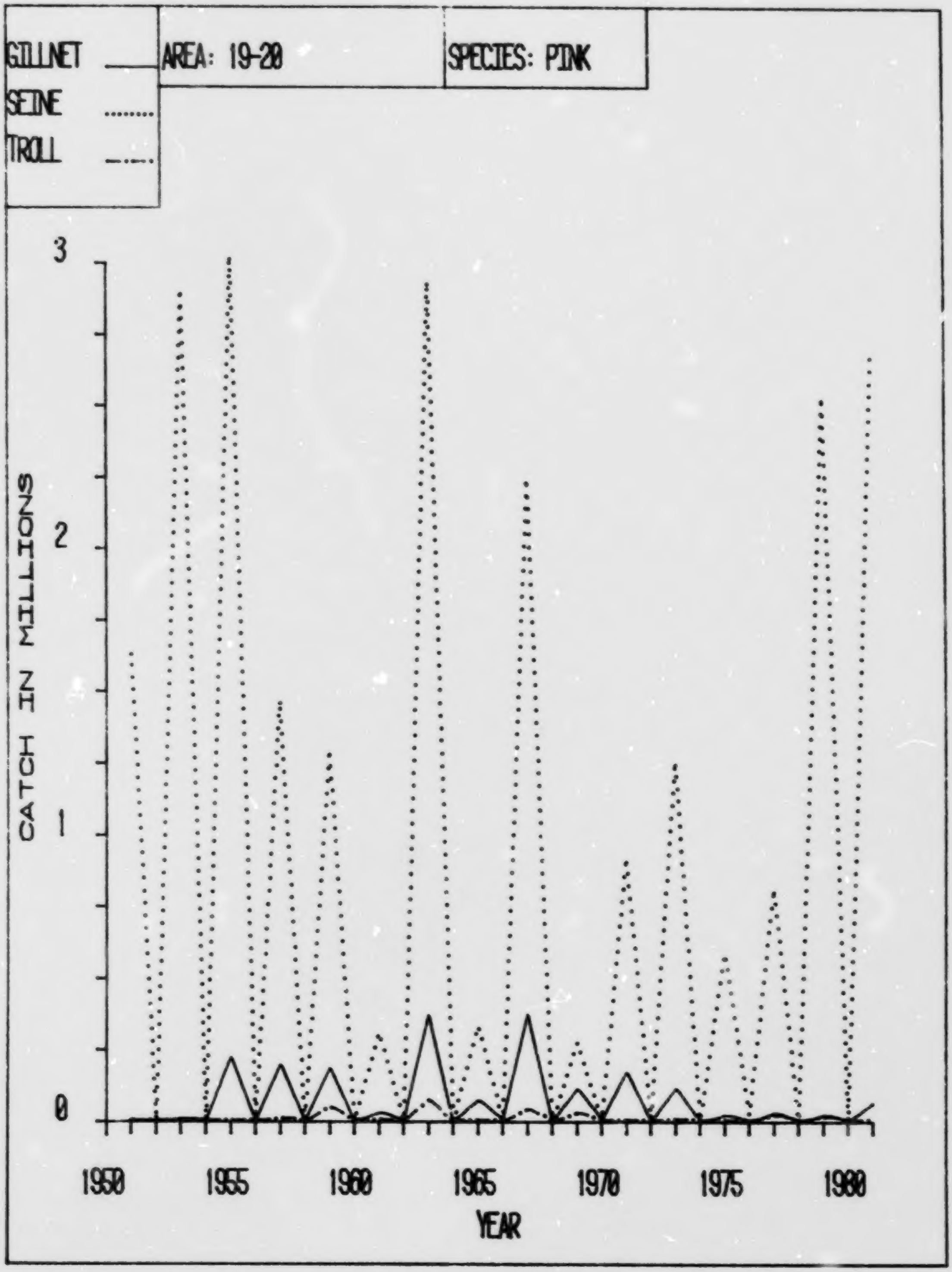

Fig. 71. Catch by gear of pink salmon in Statistical Areas 19-20.

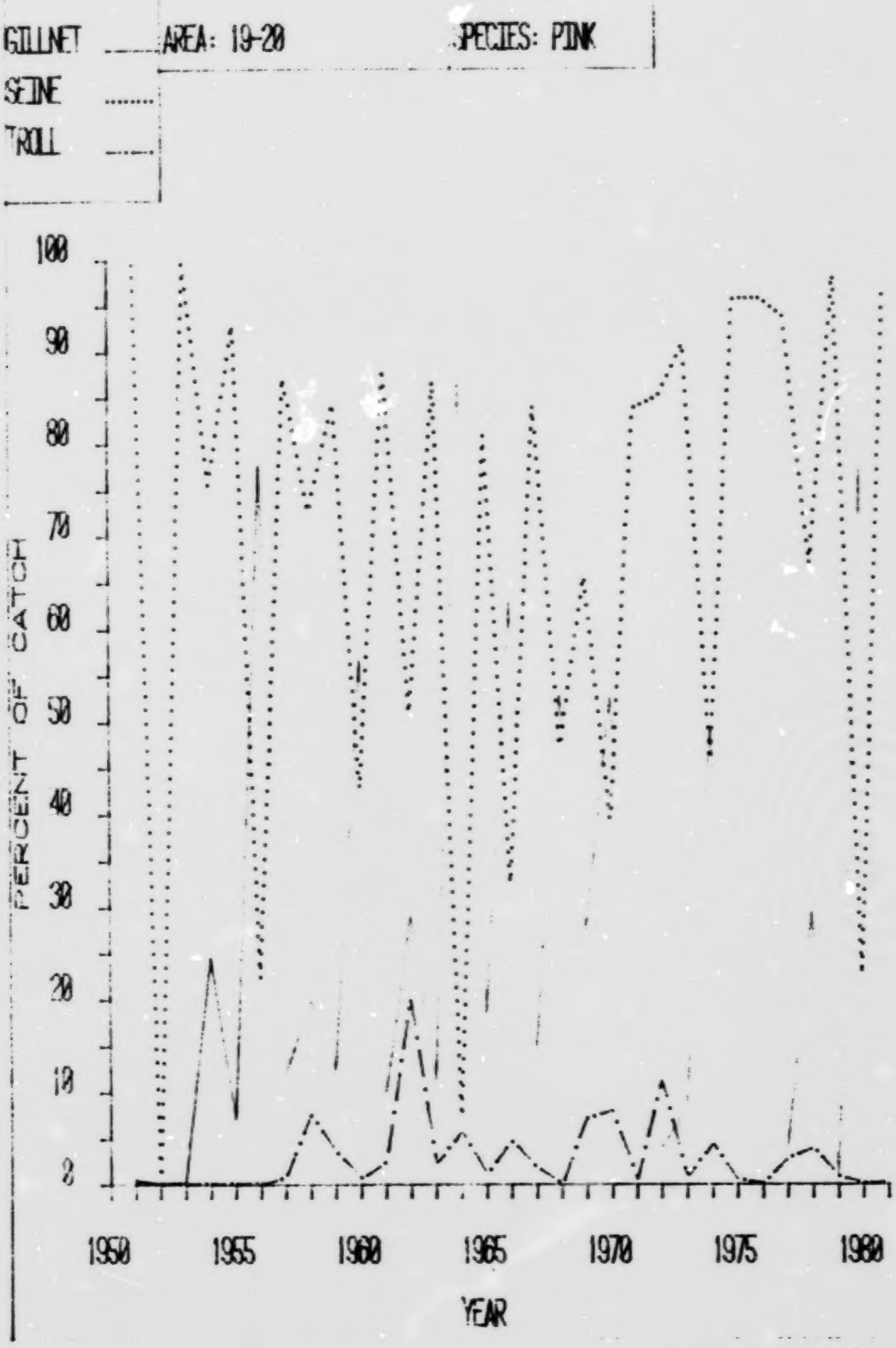

Fig. 72. Percent of total catch by gear of pink salmon in Statistical Areas 19-20.

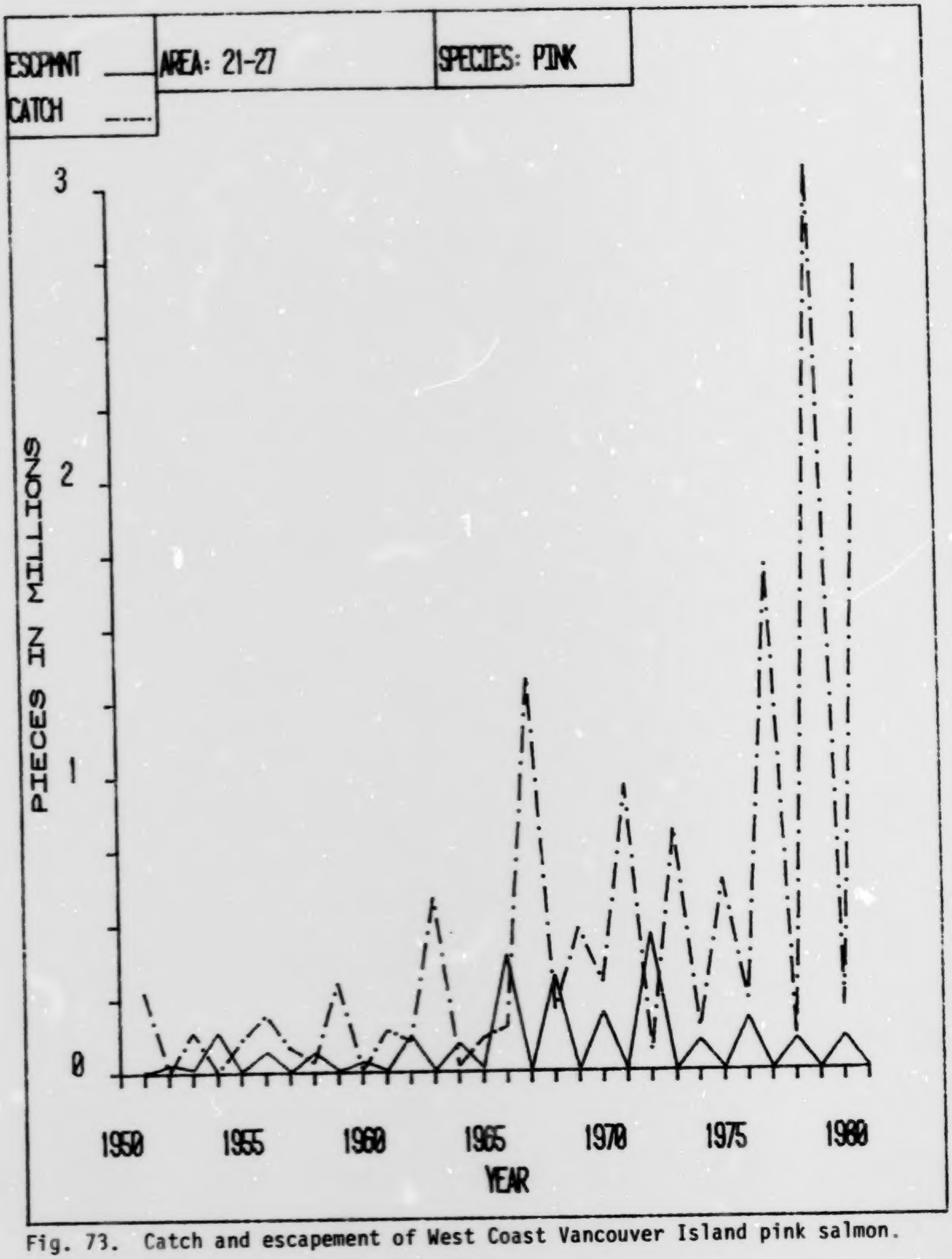

Fig. 73. Catch and escapement of West Coast Vancouver Island pink salmon.

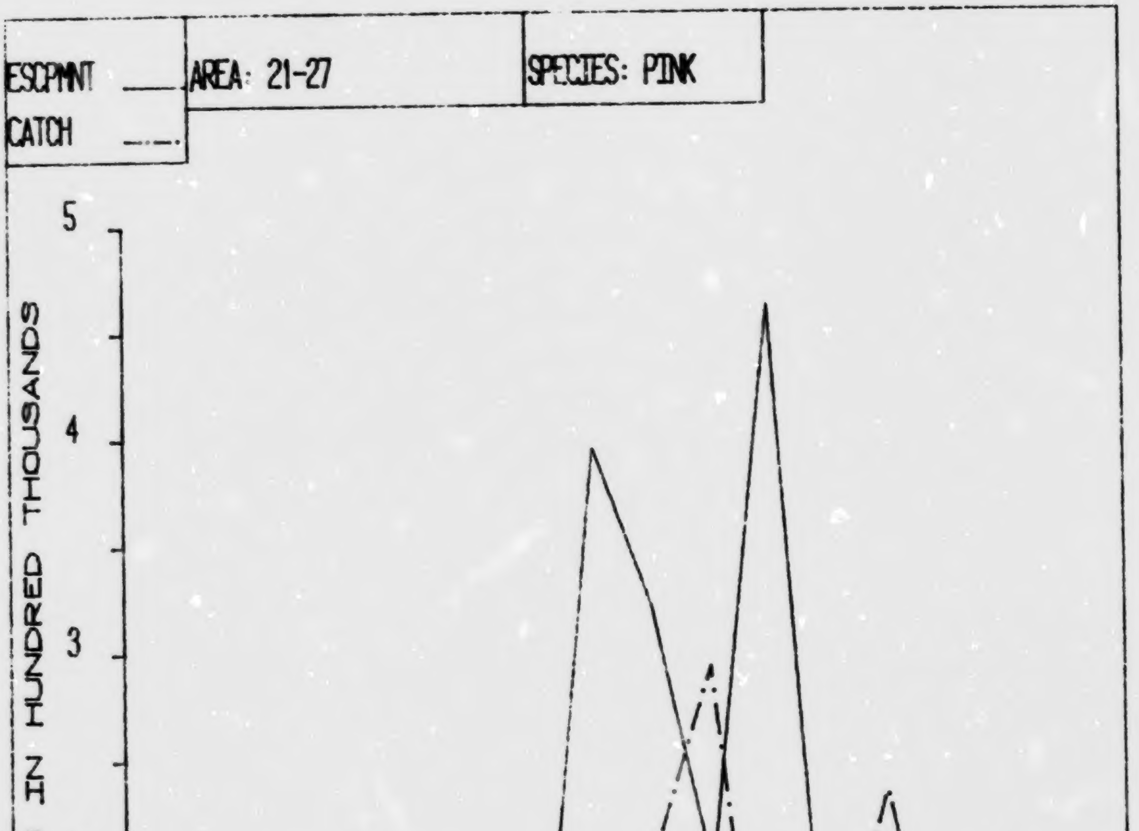

Fig. 74. Catch and escapement of even-year West Coast Vancouver Island pink salmon.

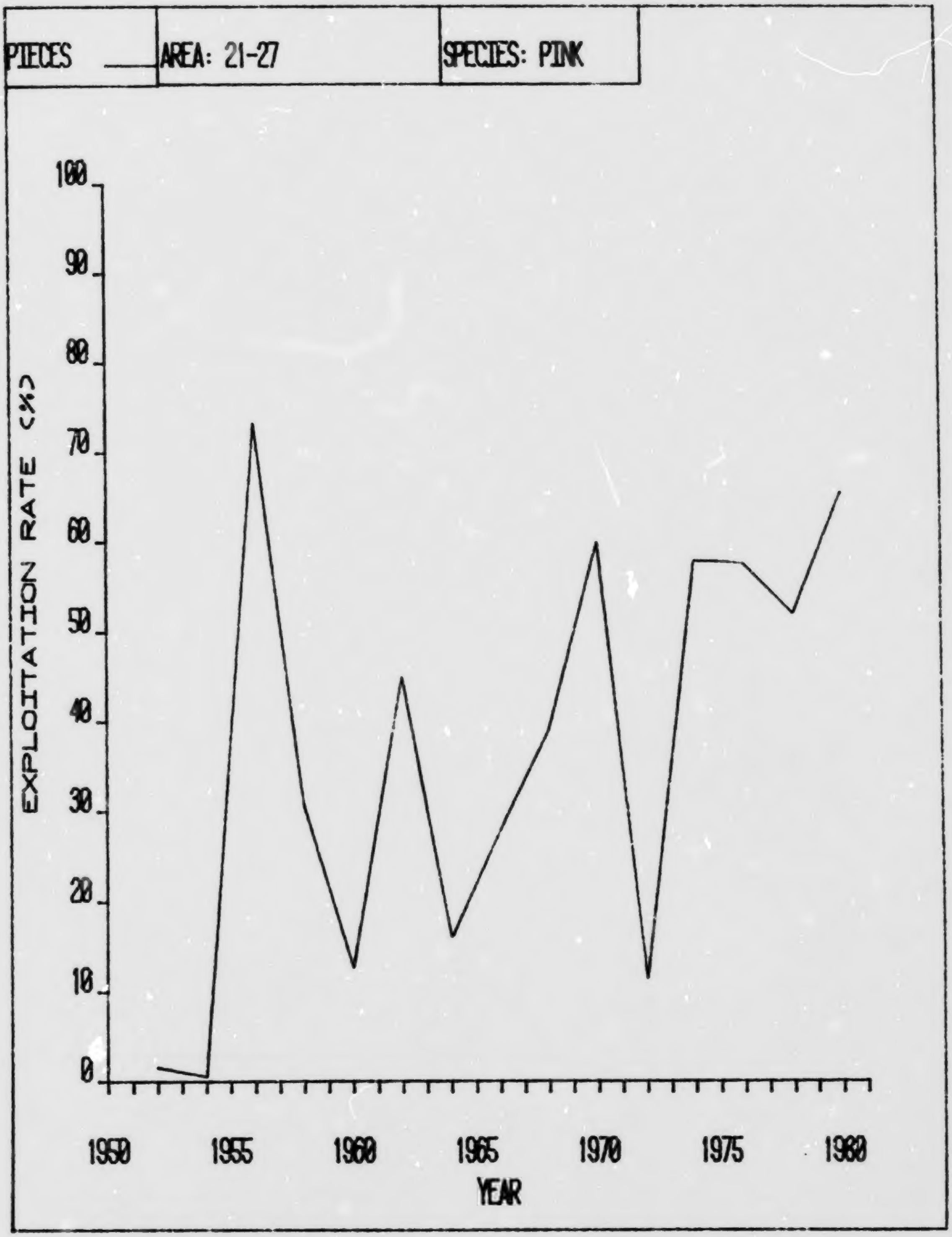

Fig. 75. Exploitation rate of even-year West Coast Vancouver Island pink salmon.

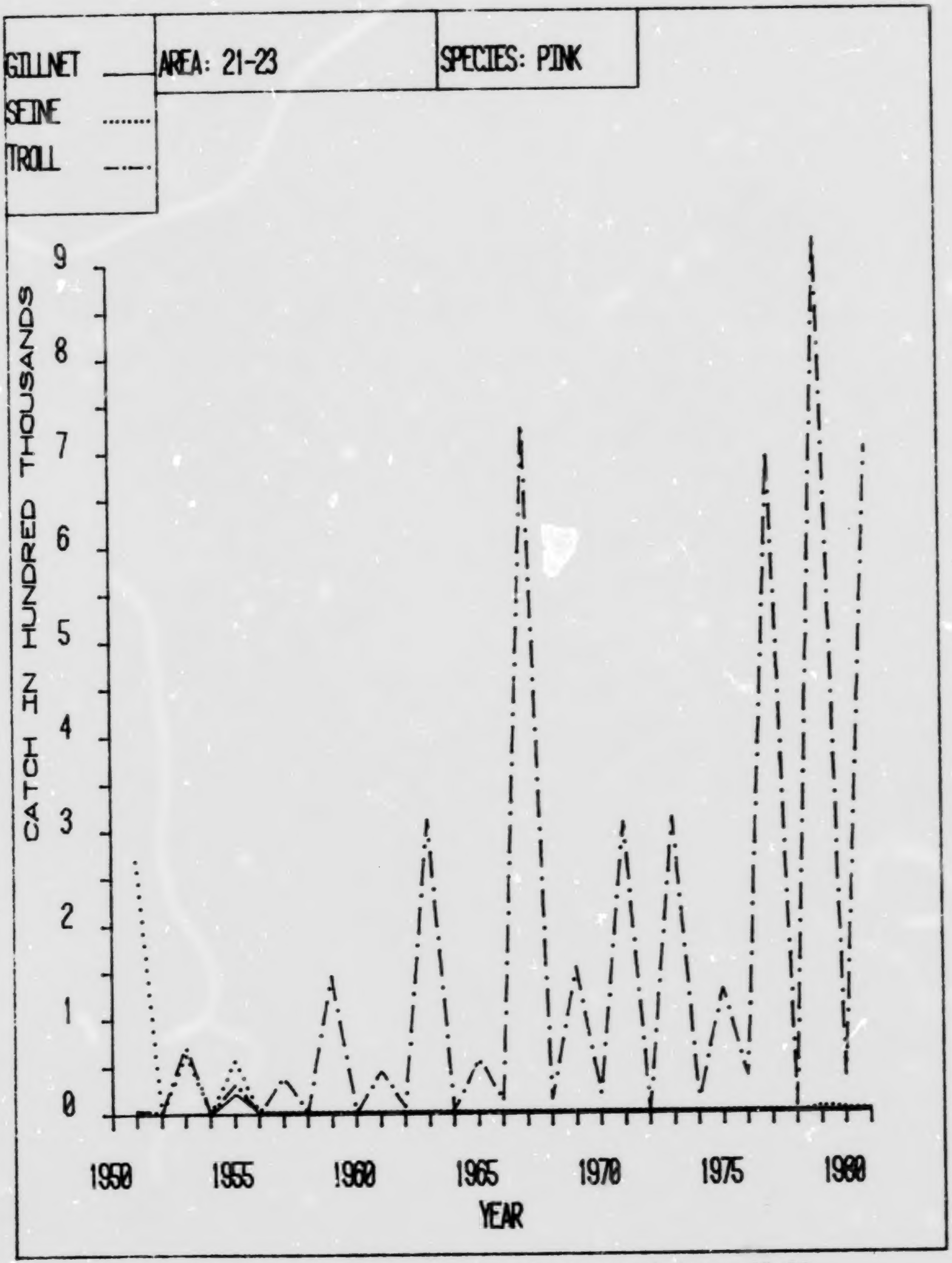

Fig. 76. Catch by gear of pink salmon in Statistical Areas 21-23.

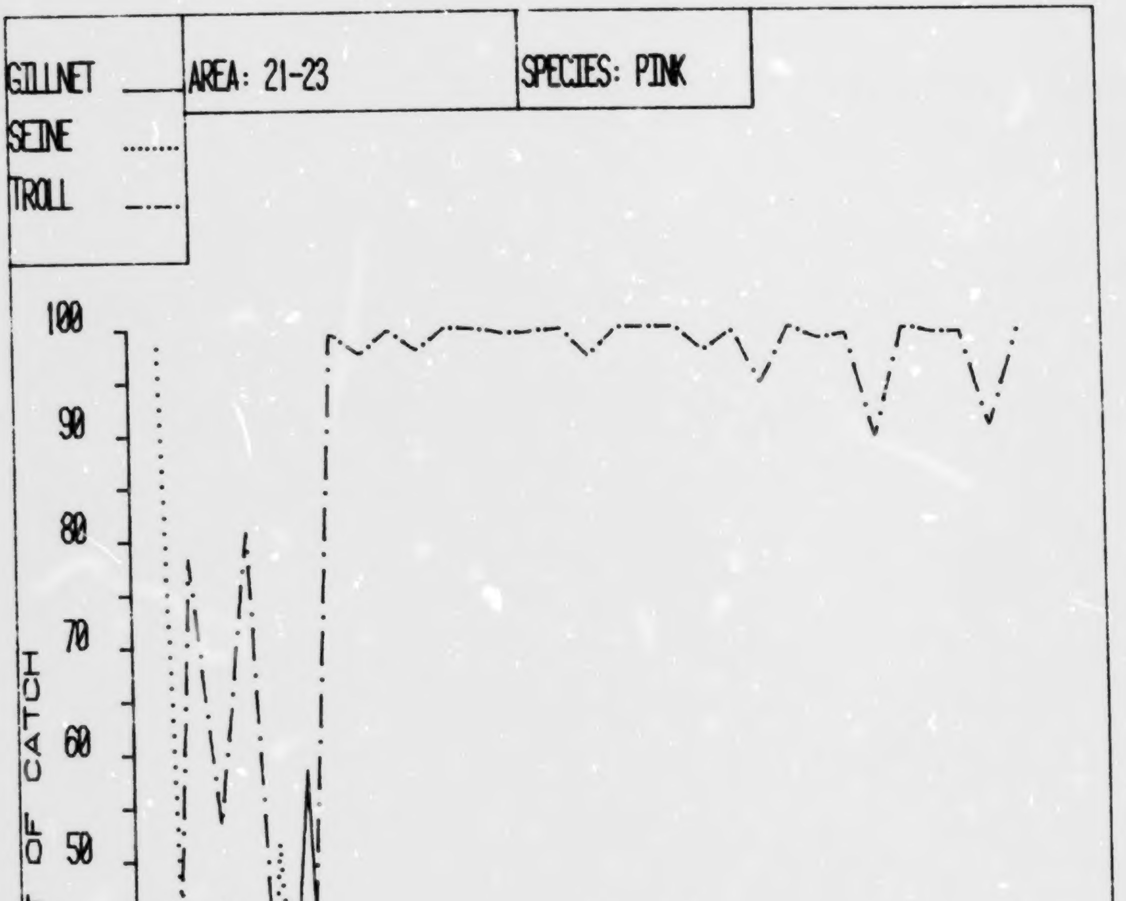

Fig. 77. Percent of total catch by gear of pink salmon in Statistical Areas 21-23.

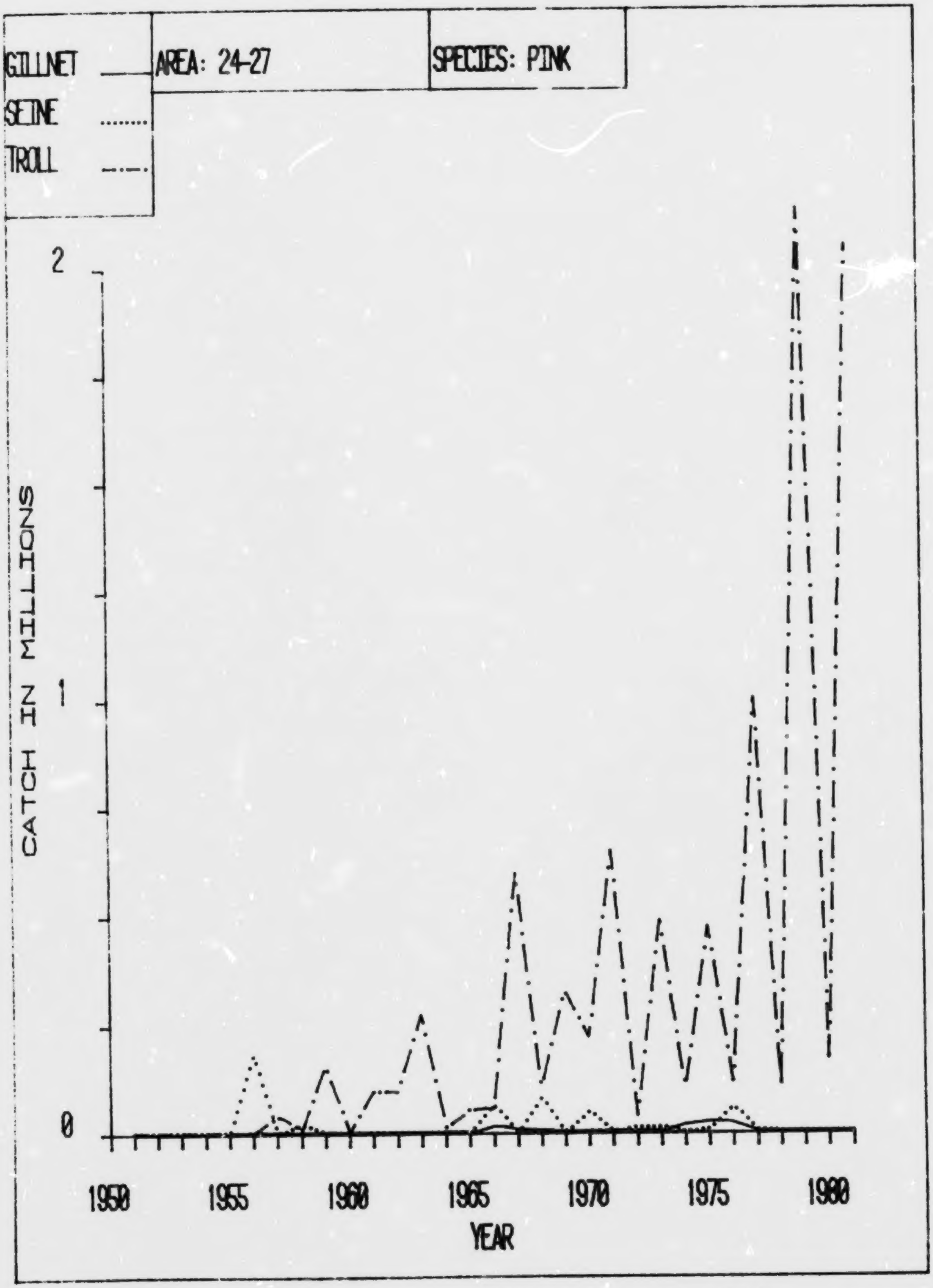

Fig. 78. Catch by gear of pink salmon in Statistical Areas 24-27.

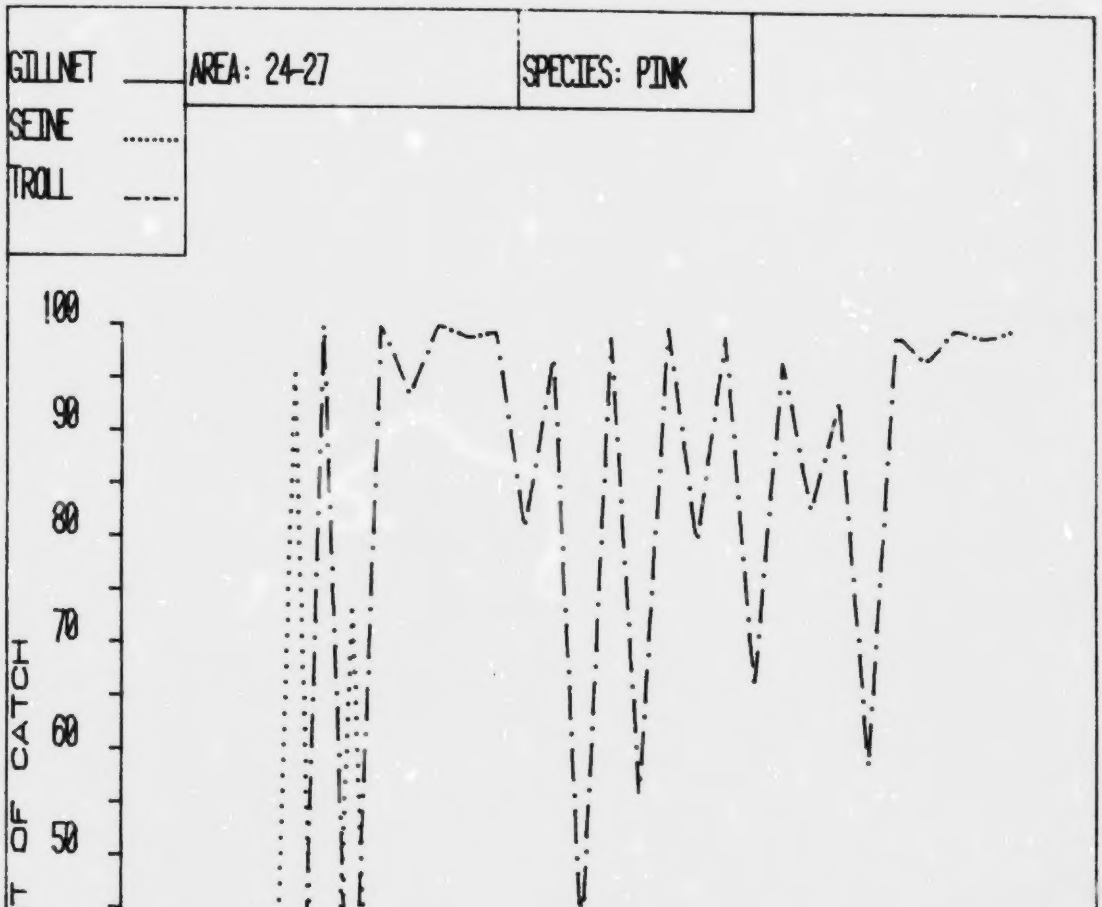

Fig. 79. Percent of total catch by gear of pink salmon in Statistical Areas 24-27.

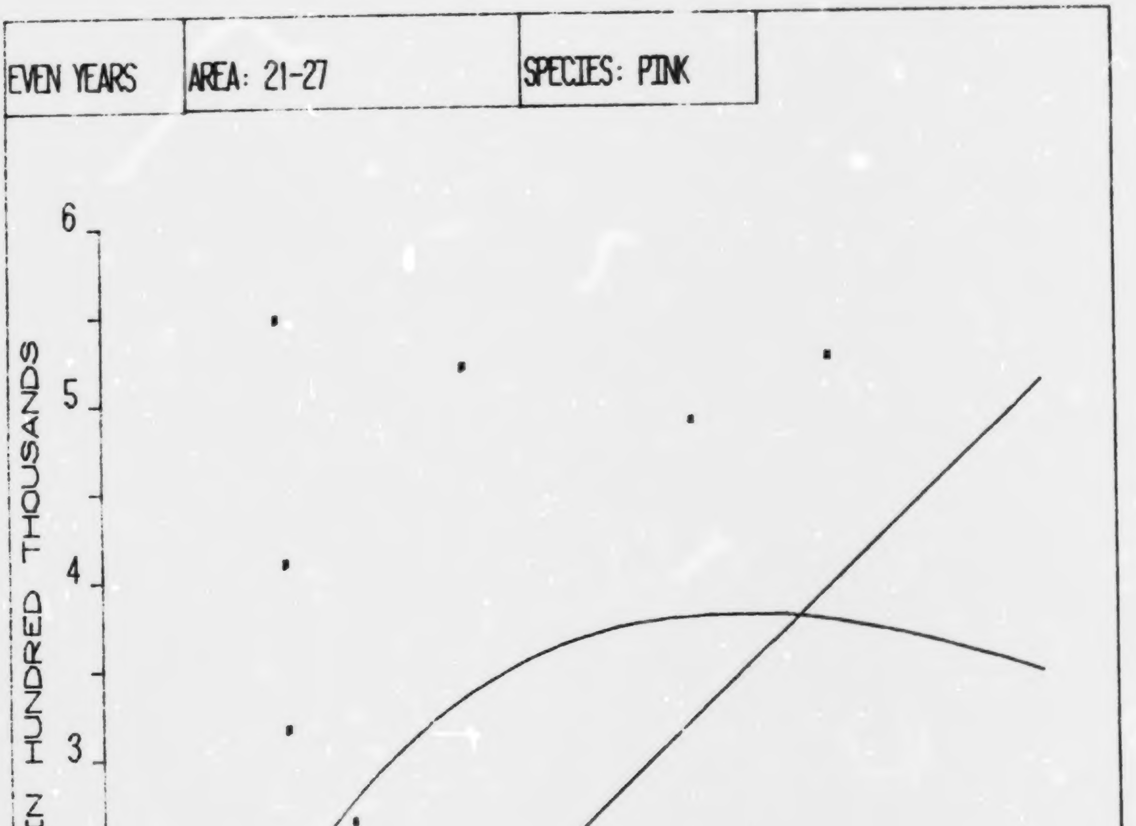

Fig. 80. Stock and recruitment relation for even-numbered broodyears of West Coast Vancouver Island pink salmon, 1950-1978.

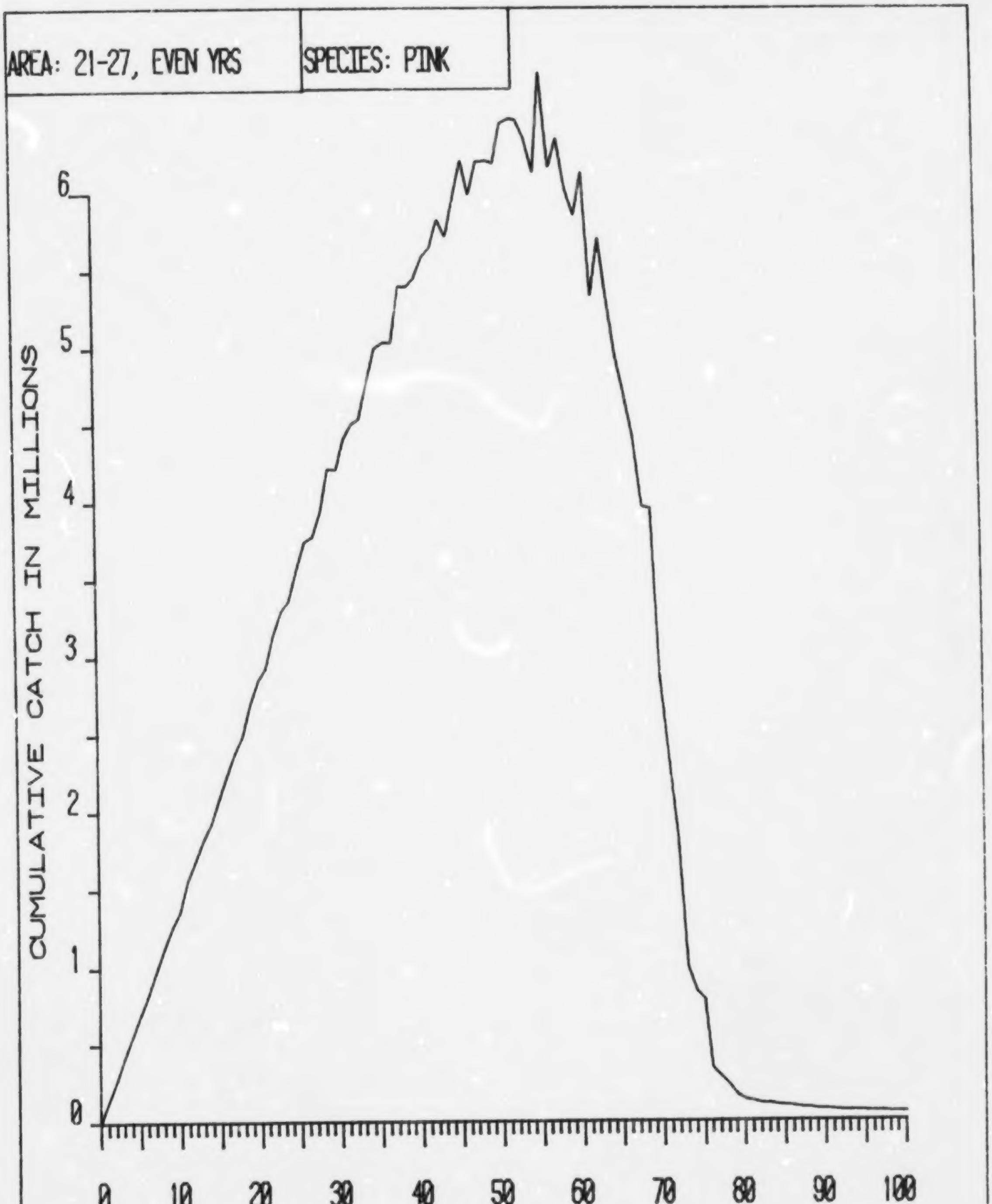

Fig. 81. Projected cumulative yield during 1960-2020 by harvesting at constant exploitation rate in each year for even-year West Coast Vancouver Island pink salmon.

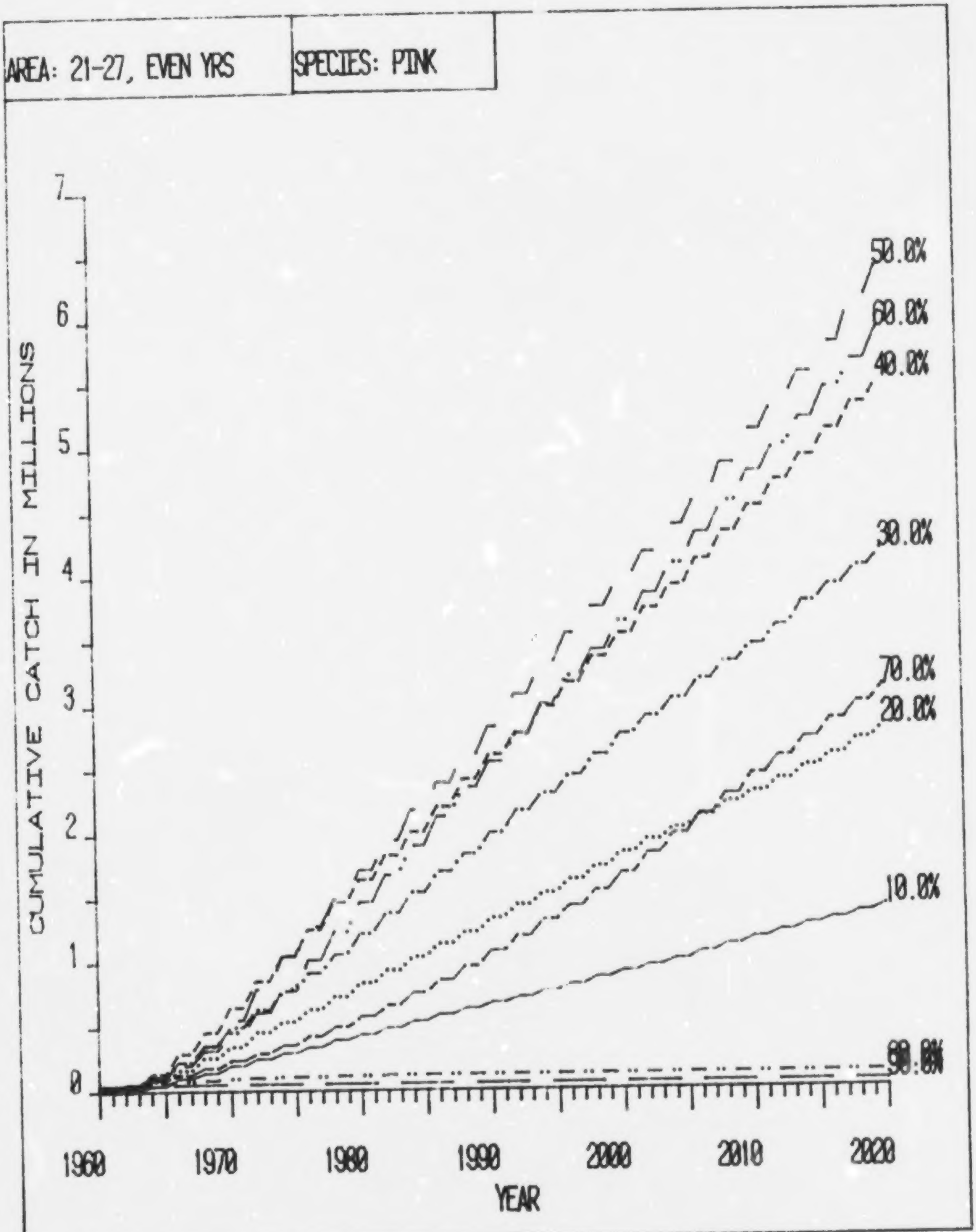

Fig. 82. Summary of yields under a 60-year projection of exploitation rates of 10-90% for even-year West Coast Vancouver Island pink salmon.

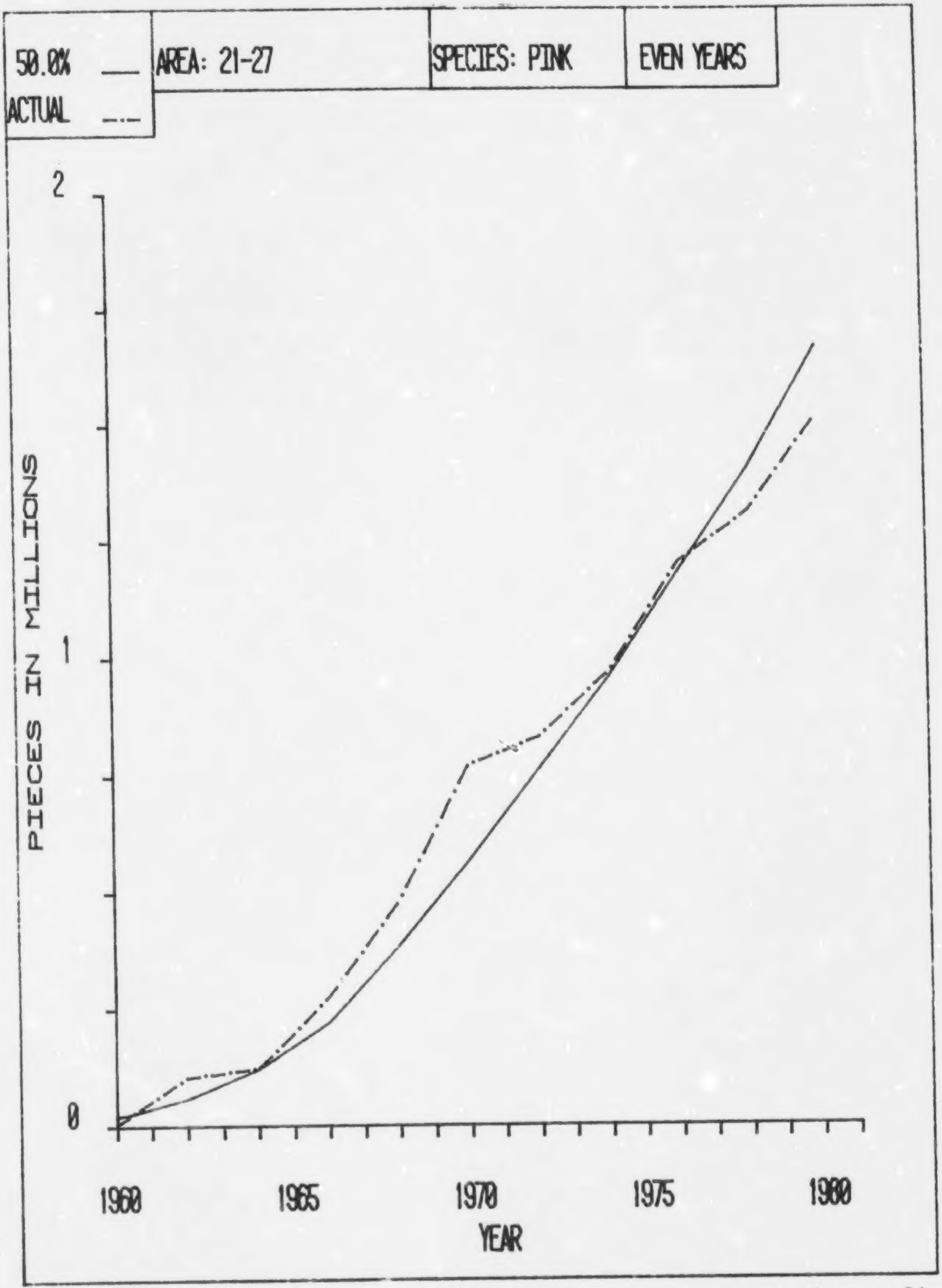

Fig. 83. Actual cumulative catch and projected cumulative catch under a policy of 50% annual exploitation rate during 1960-1980 of even-year West Coast Vancouver Island pink salmon.

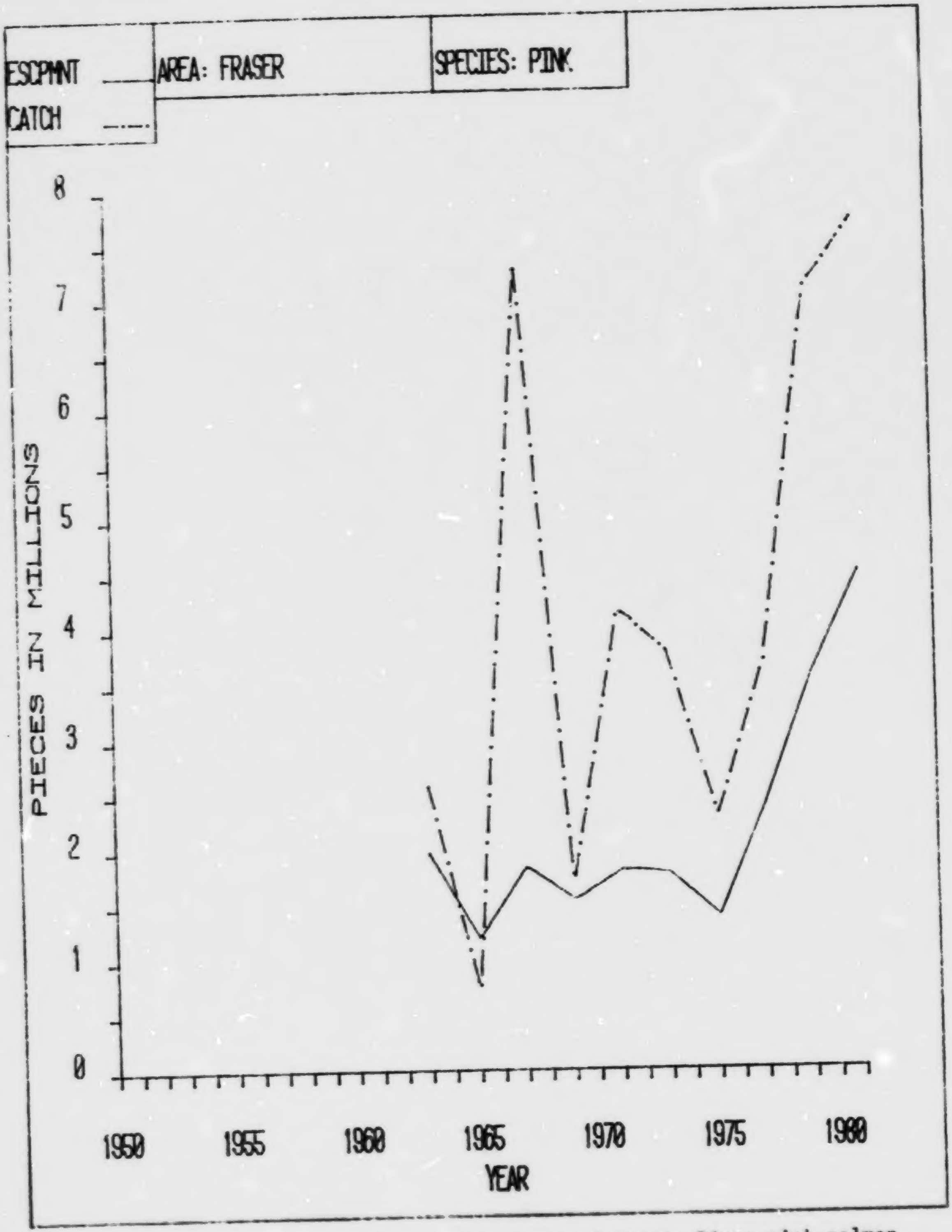

Fig. 84. Convention Area catch and escapement of Fraser River pink salmon.

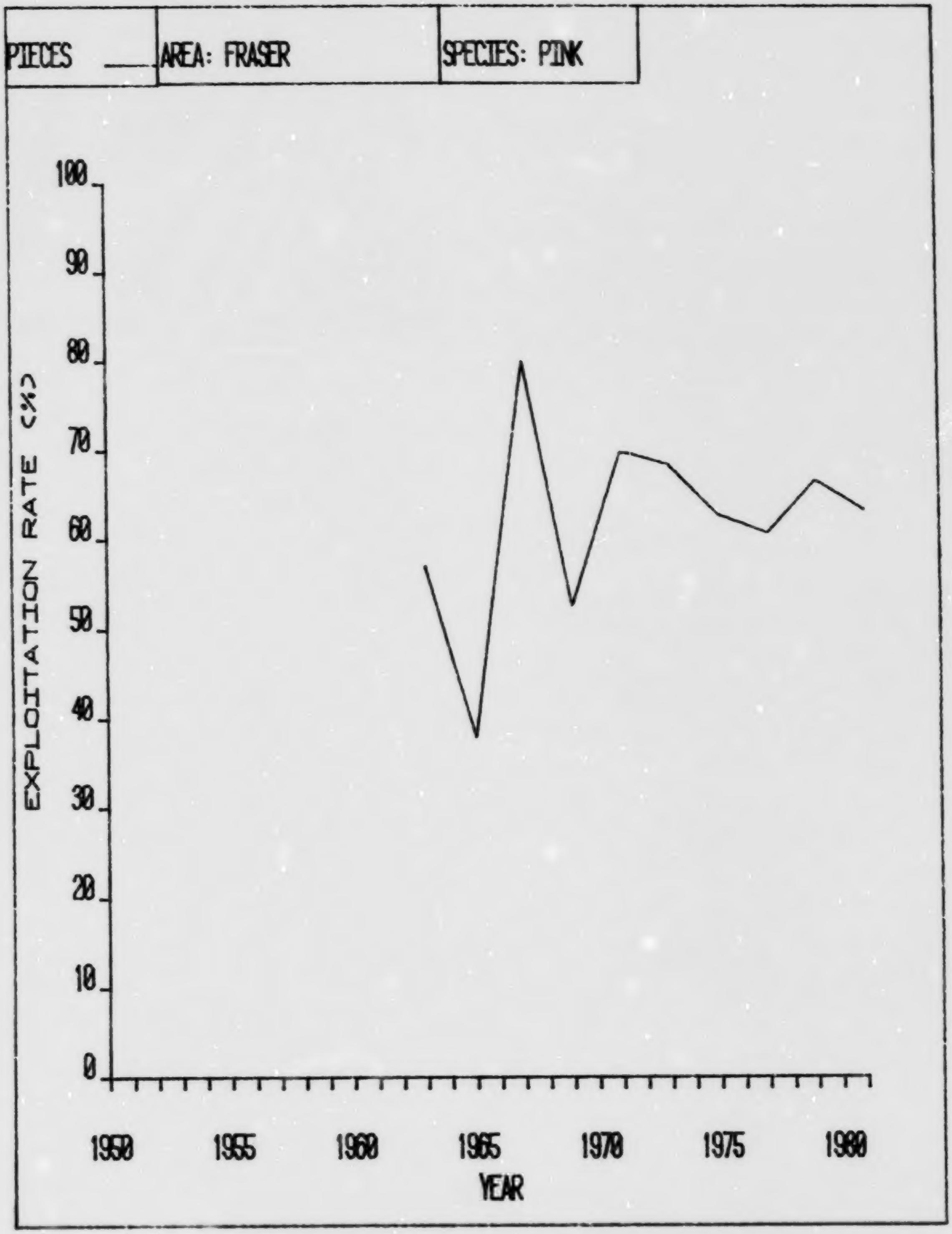

Fig. 85. Convention Area exploitation rate of Fraser River pink salmon.

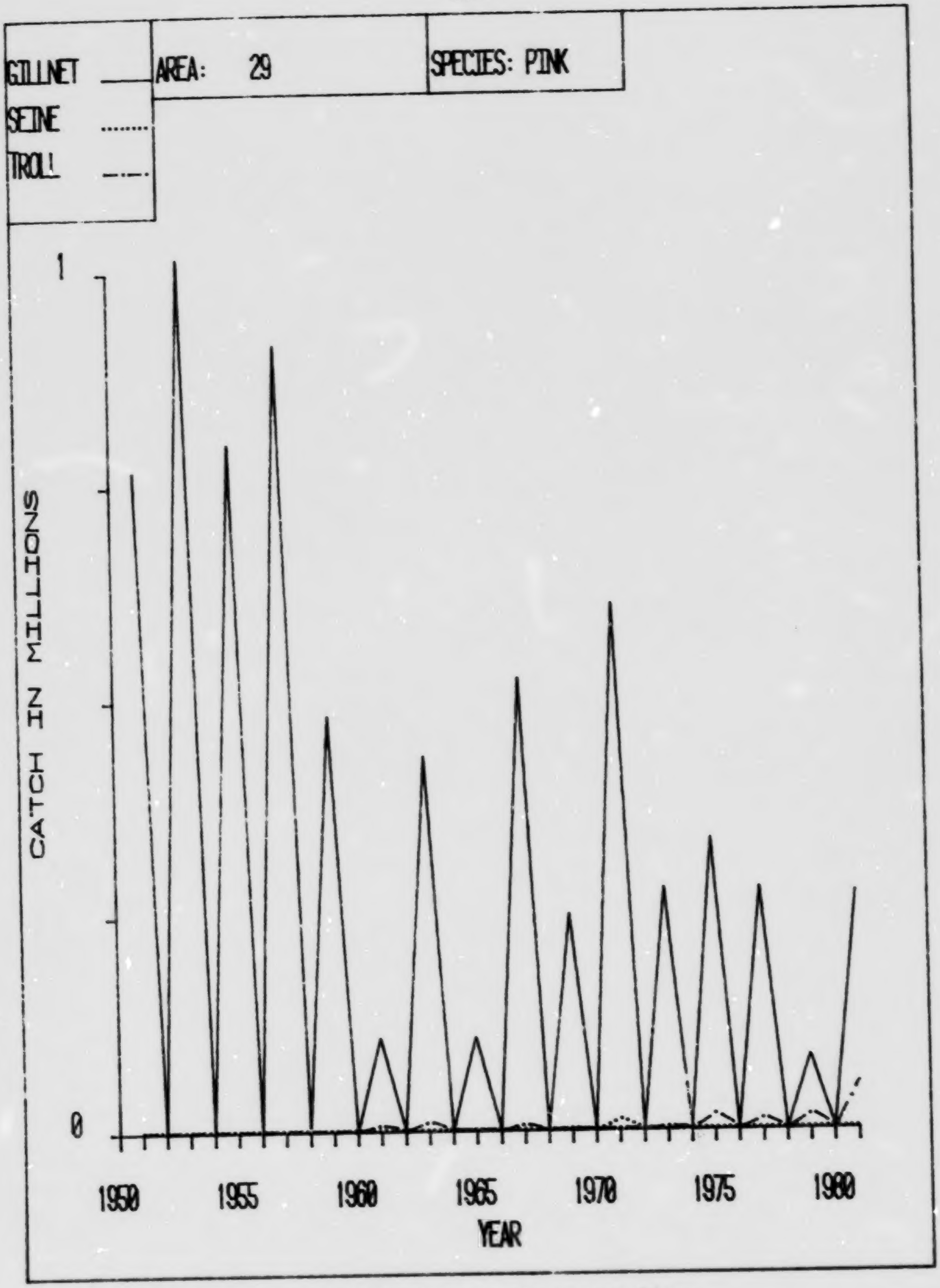

Fig. 86. Catch by gear of pink salmon in the Fraser River.

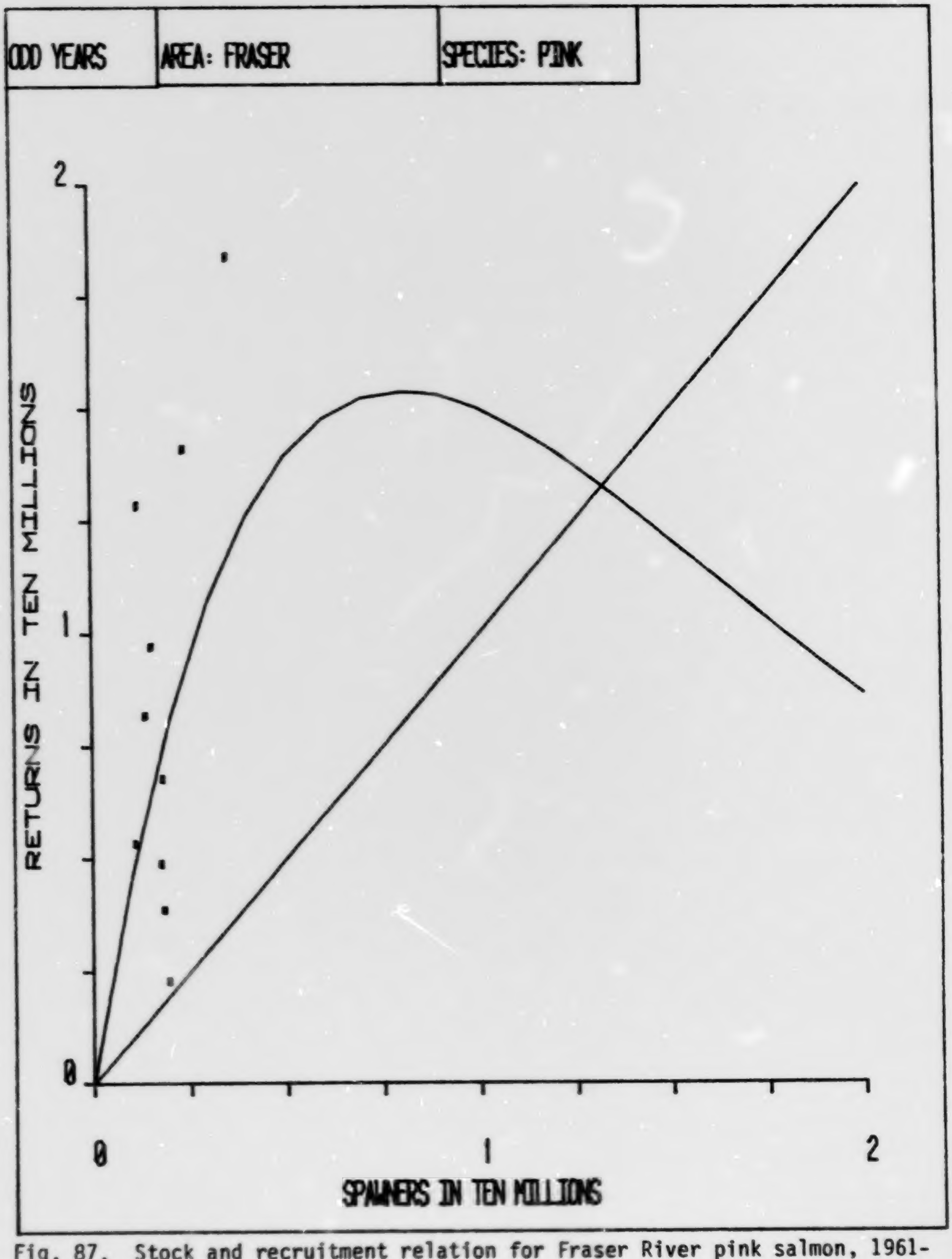

Fig. 87. Stock and recruitment relation for Fraser River pink salmon, 1961-1979 broodyears.

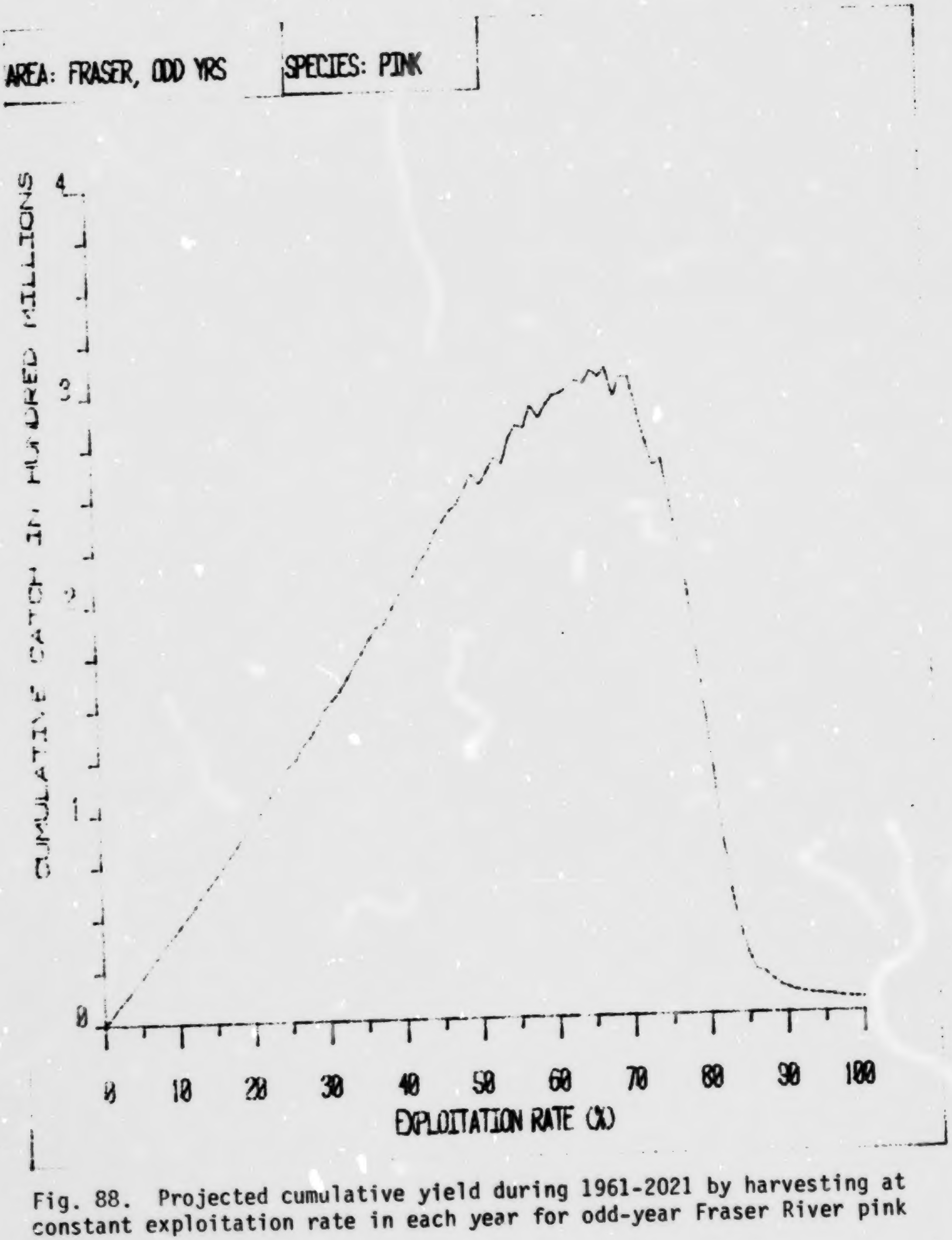

Fig. 88. Projected cumulative yield during 1961-2021 by harvesting at constant exploitation rate in each year for odd-year Fraser River pink salmon.

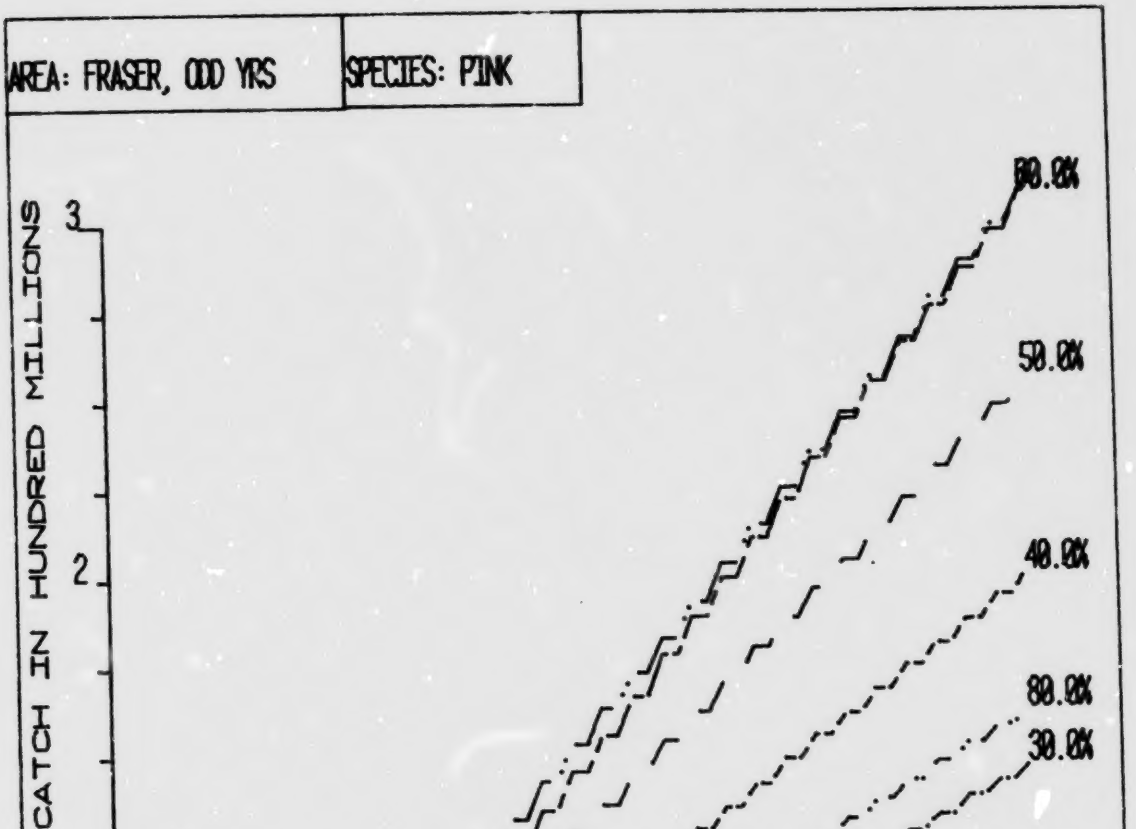

Fig. 89. Summary of yields under a 60-year projection of exploitation rates of 10-90% for odd-year Fraser River pink salmon.

APPENDIX A

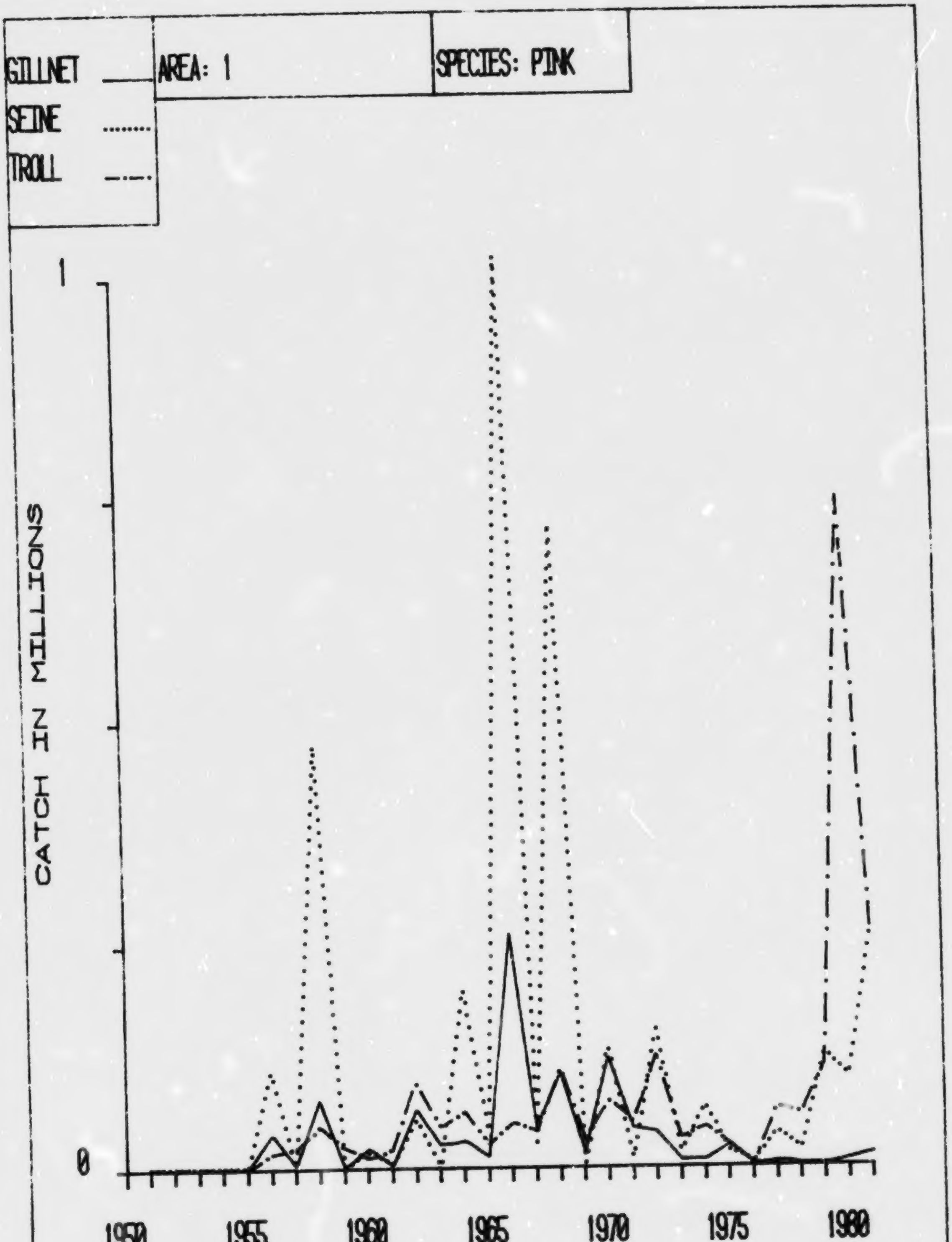

Fig. A1. Catch of pink salmon by gear in Statistical Area 1, 1951-1981.

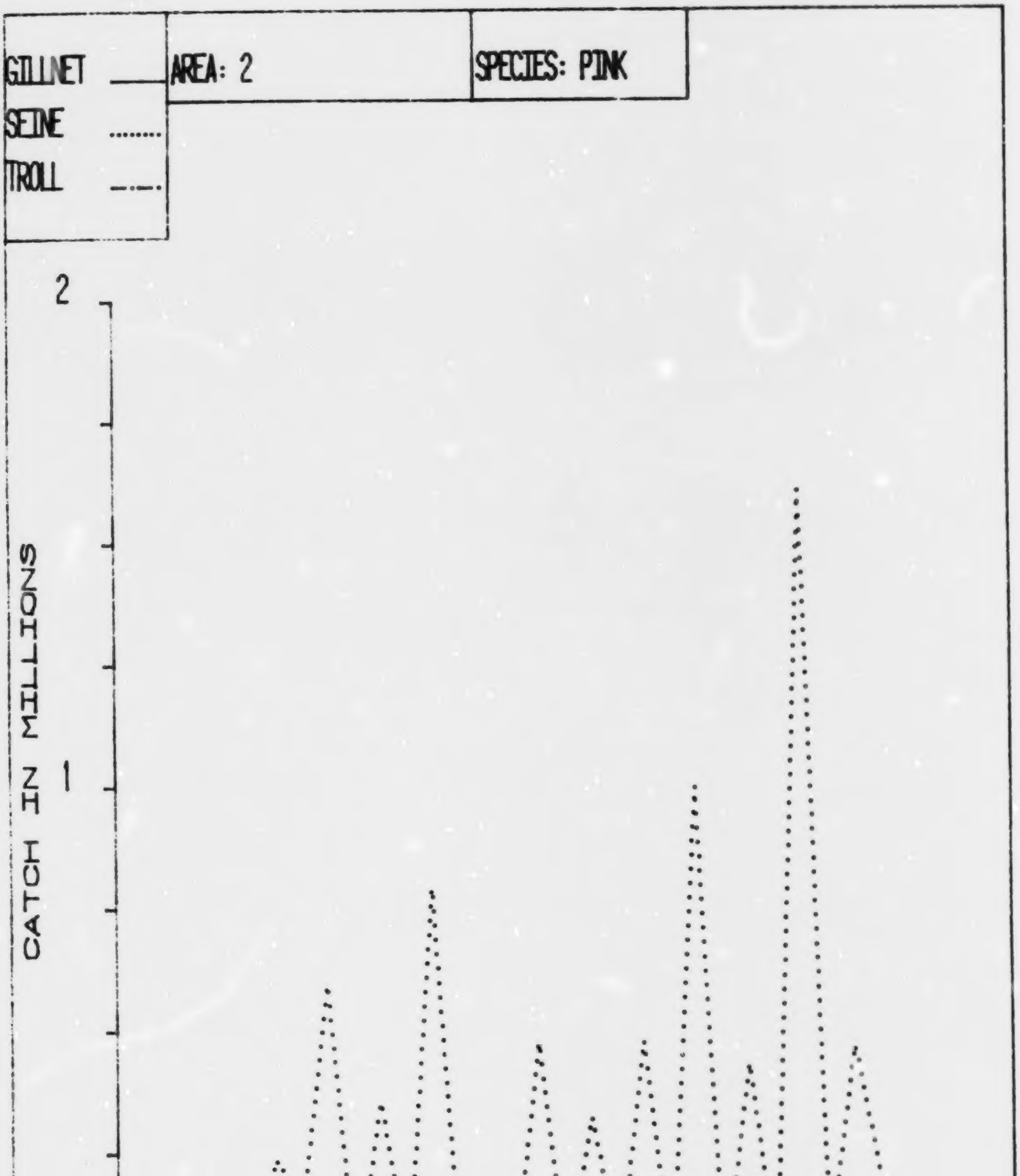

Fig. A2. Catch of pink salmon by gear in Statistical Area 2, 1951-1981.

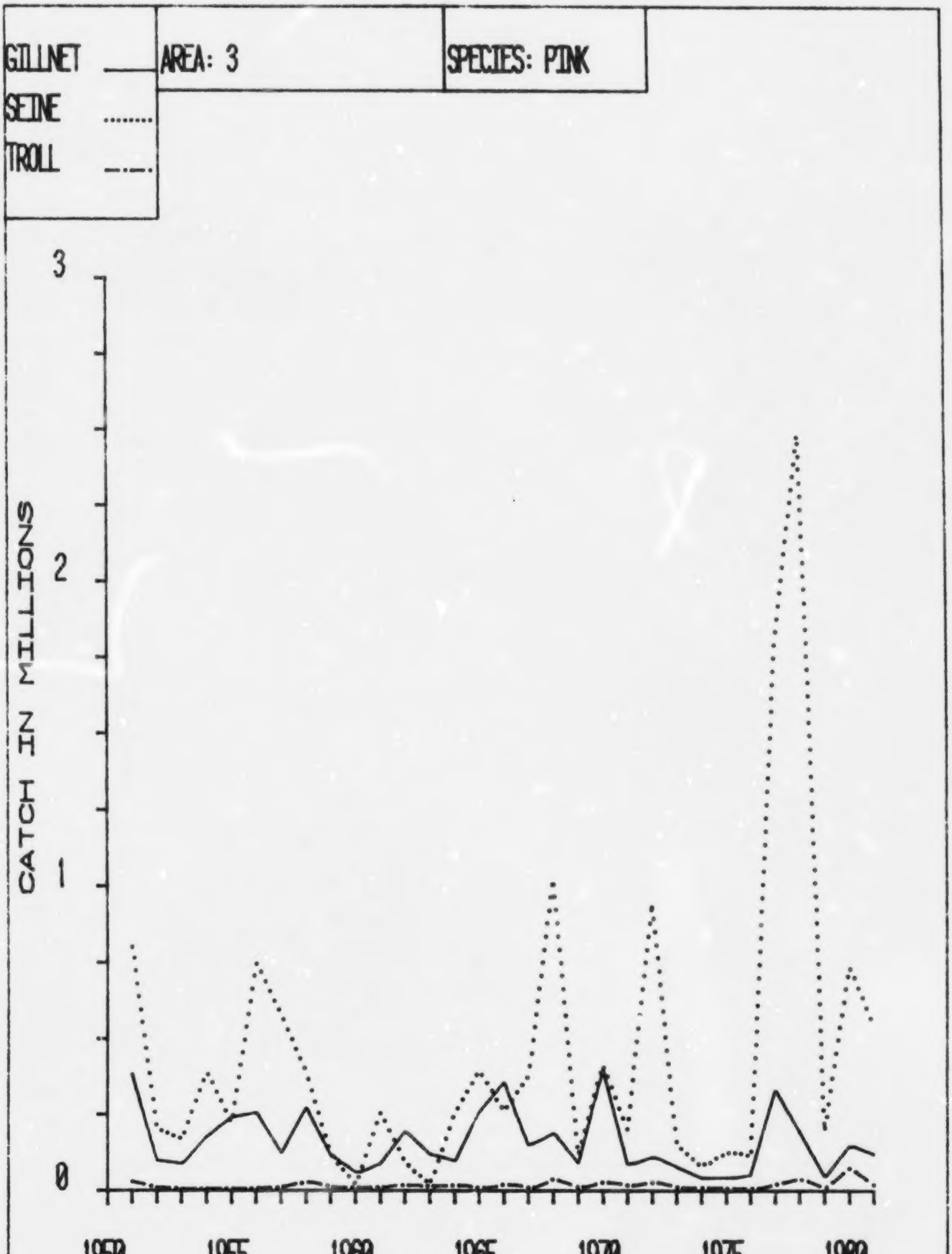

Fig. A3. Catch of pink salmon by gear in Statistical Area 3, 1951-1981.

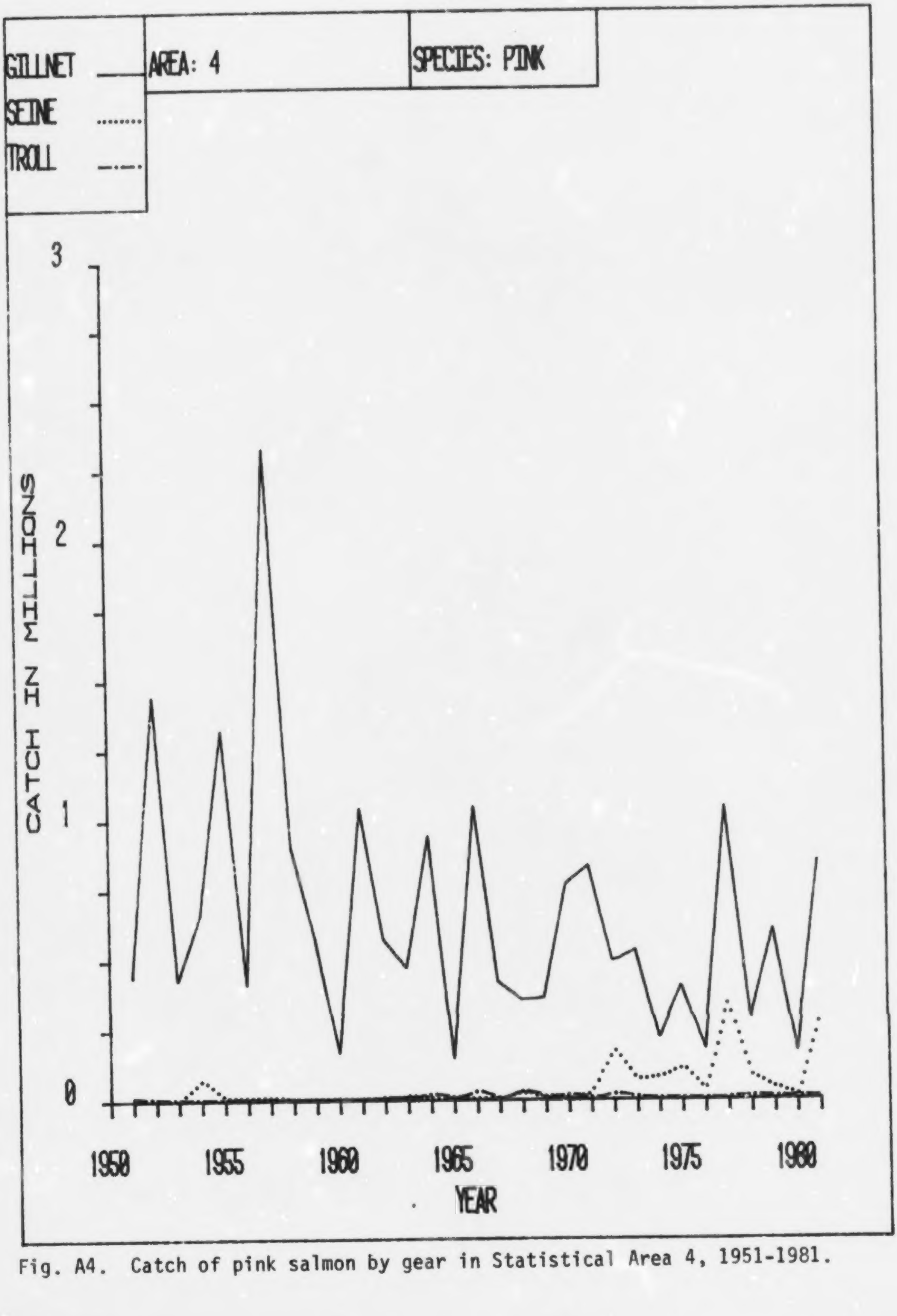

Fig. A4. Catch of pink salmon by gear in Statistical Area 4, 1951-1981.

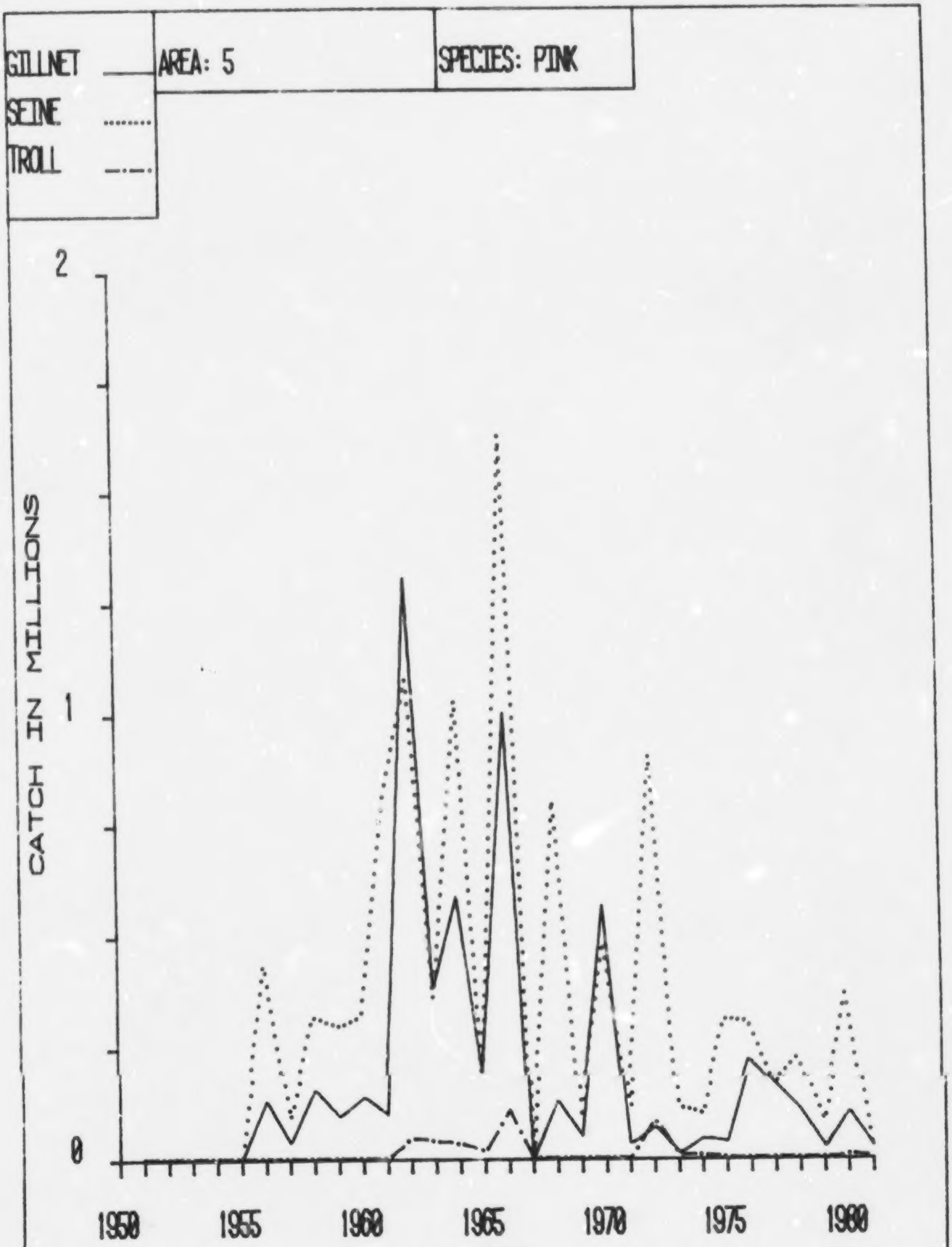

Fig. A5. Catch of pink salmon by gear in Statistical Area 5, 1951-1981.

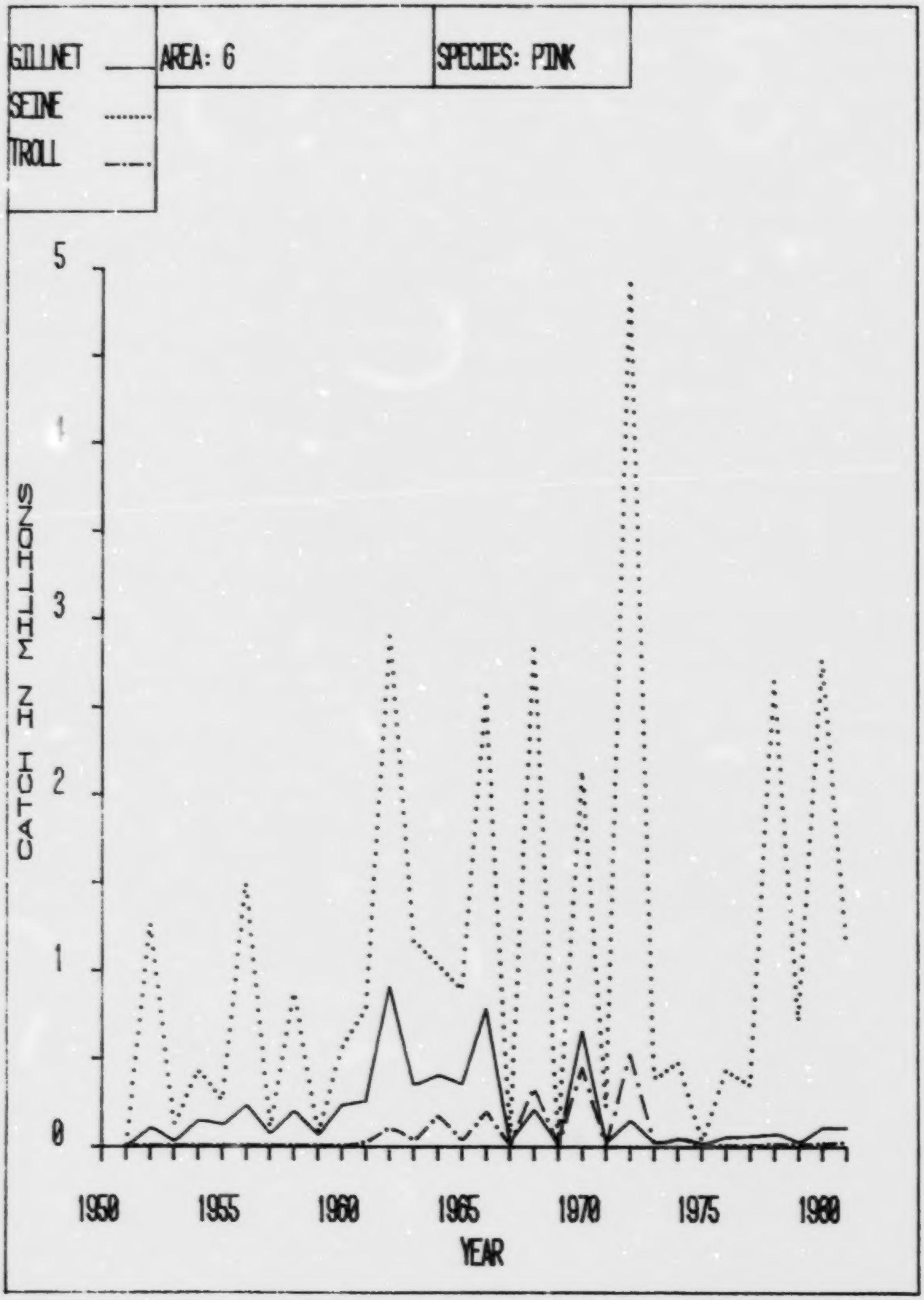

Fig. A6. Catch of pink salmon by gear in Statistical Area 6, 1951-1981.

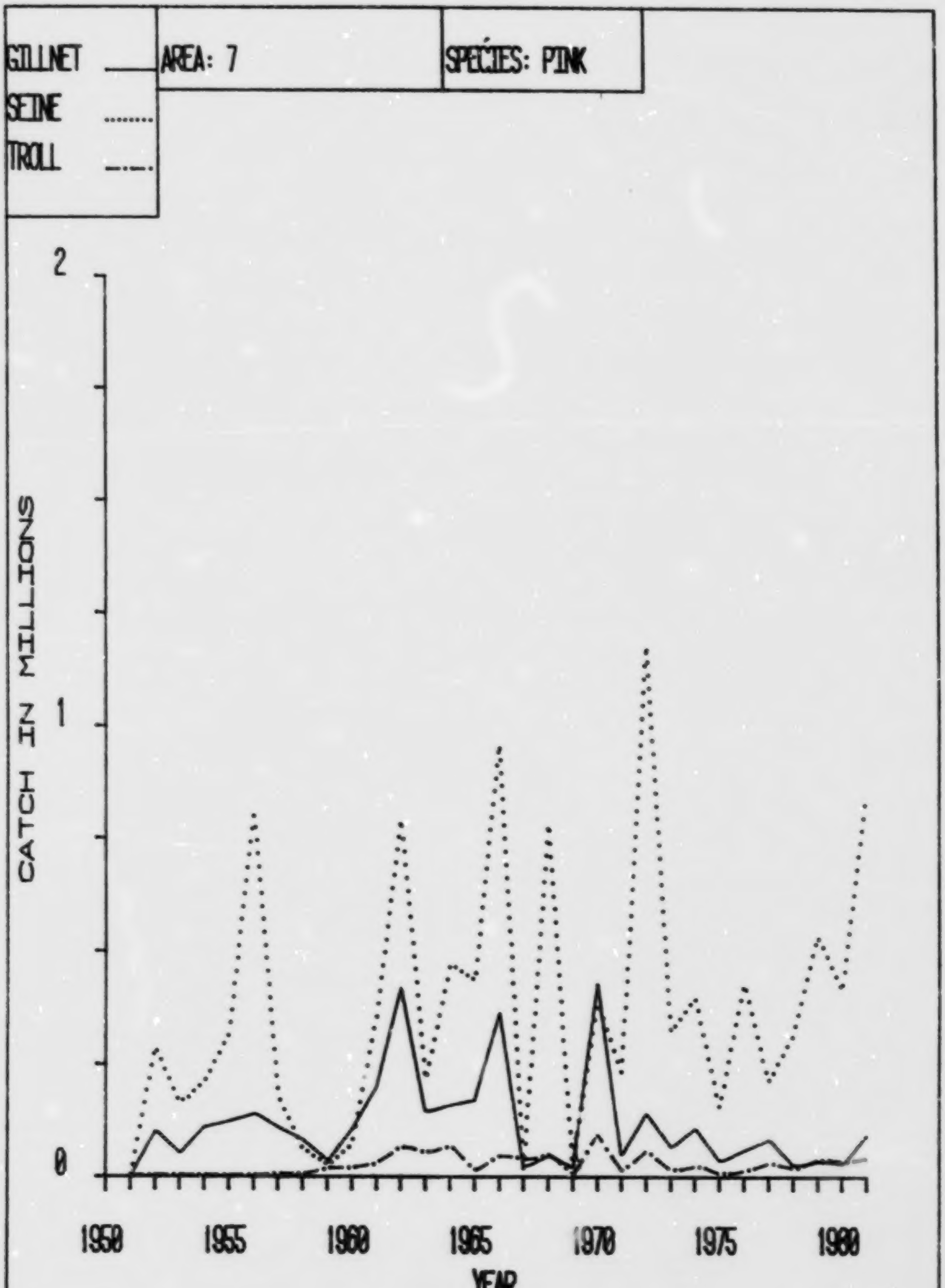

Fig. A7. Catch of pink salmon by gear in Statistical Area 7, 1951-1981.

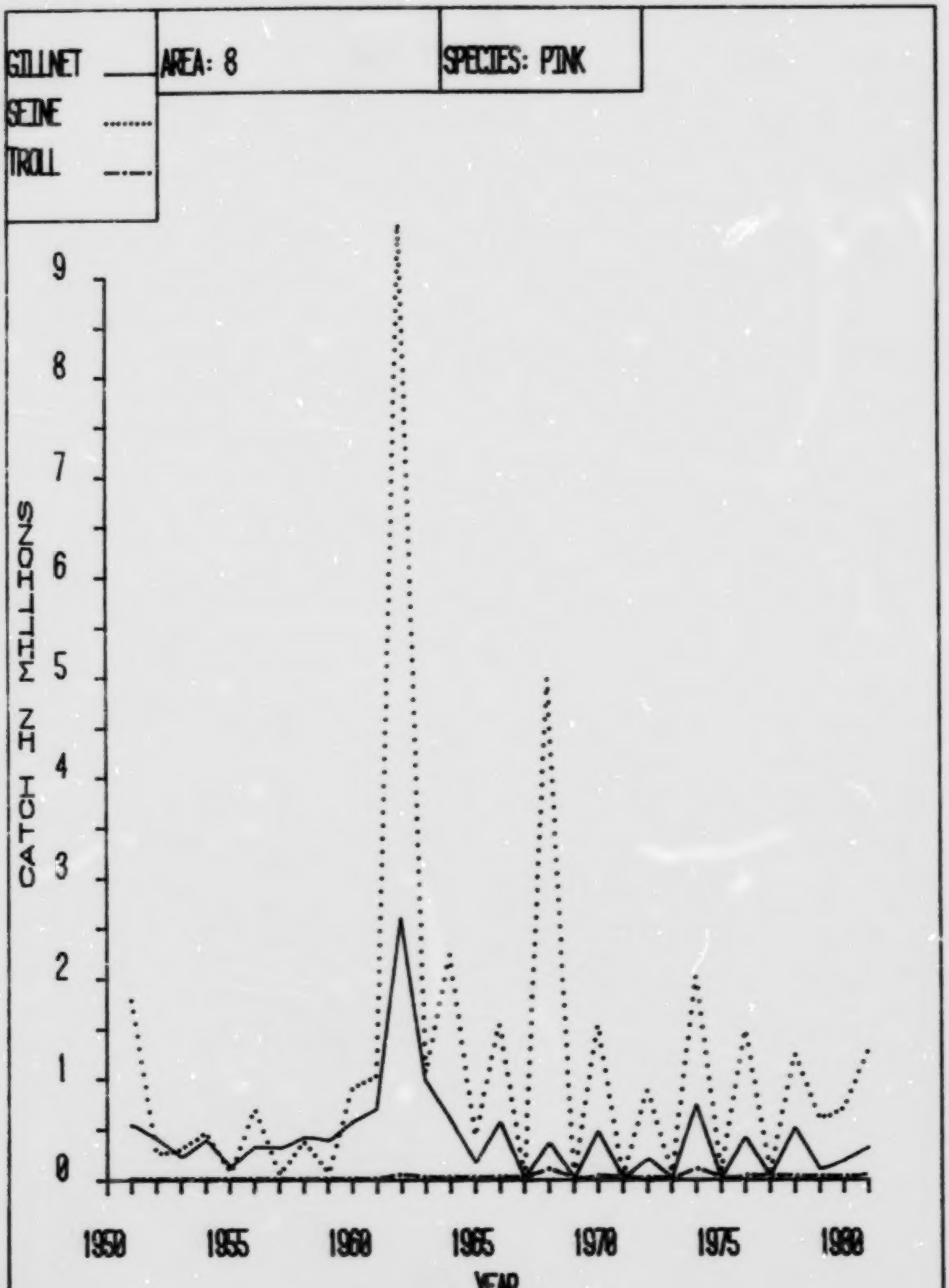

Fig. A8. Catch of pink salmon by gear in Statistical Area 8, 1951-1981.

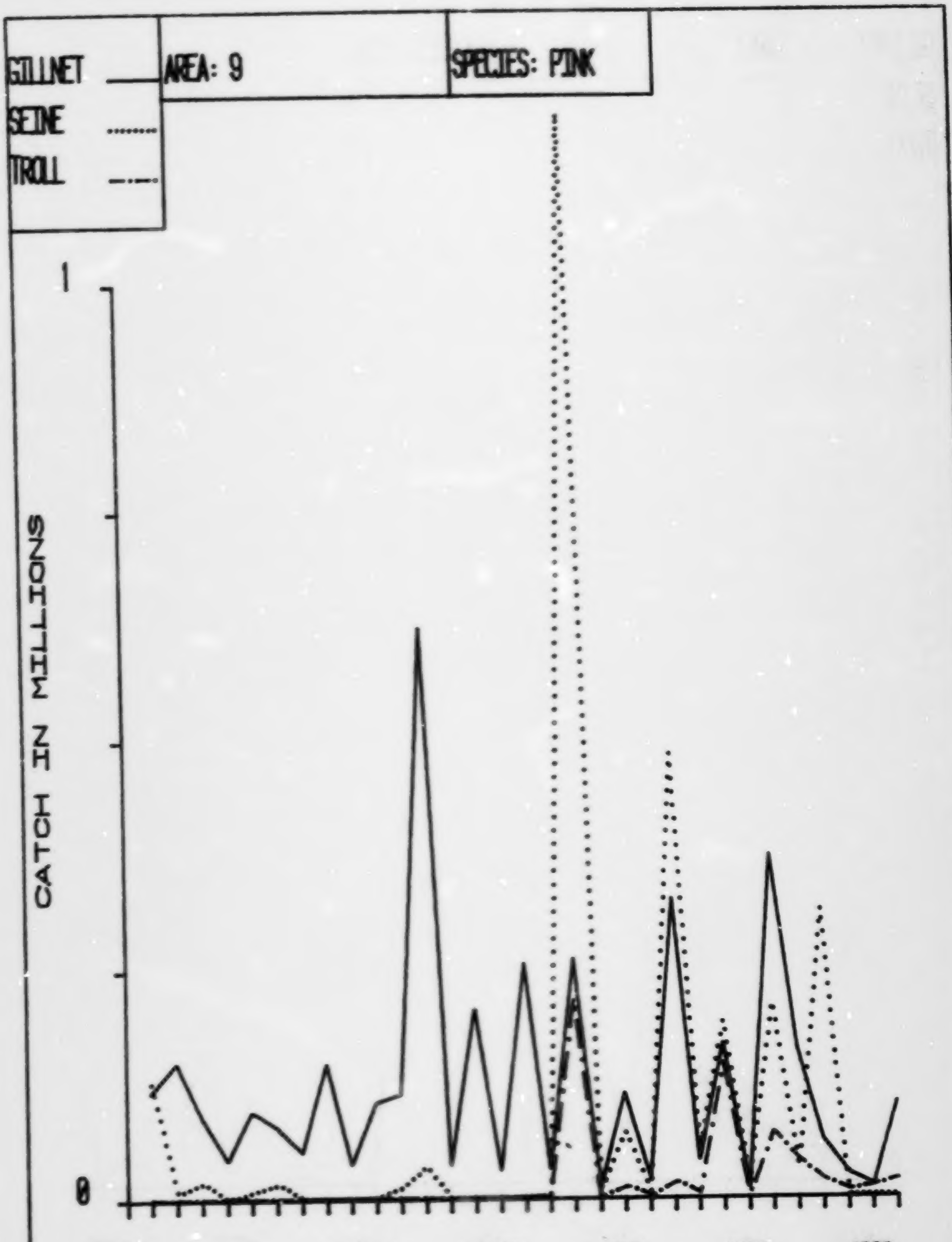

Fig. A9. Catch of pink salmon by gear in Statistical Area 9, 1951-1981.

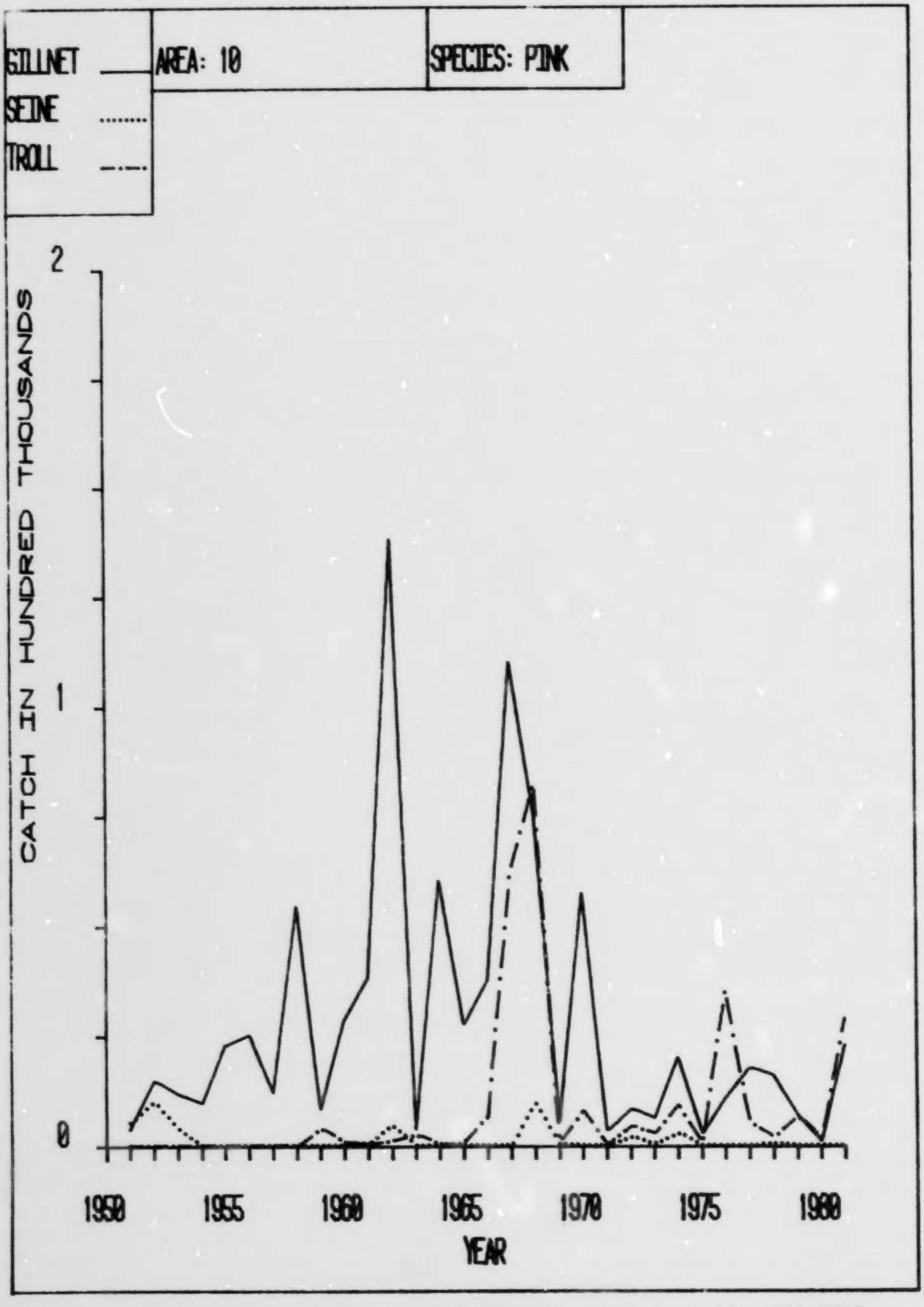

Fig. A10. Catch of pink salmon by gear in Statistical Area 10, 1951-1981.

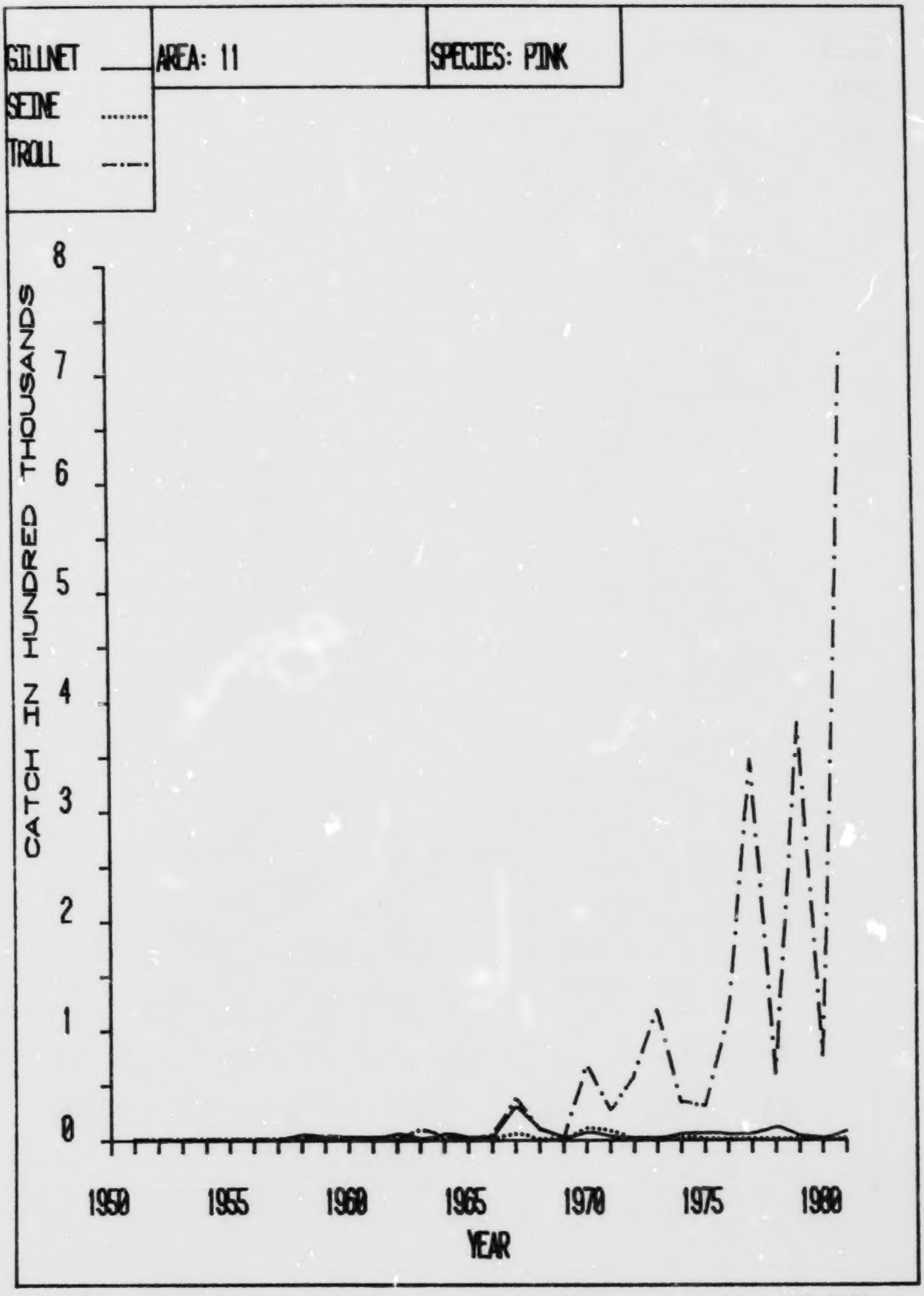

Fig. A11. Catch of pink salmon by gear in Statistical Area 11, 1951-1981.

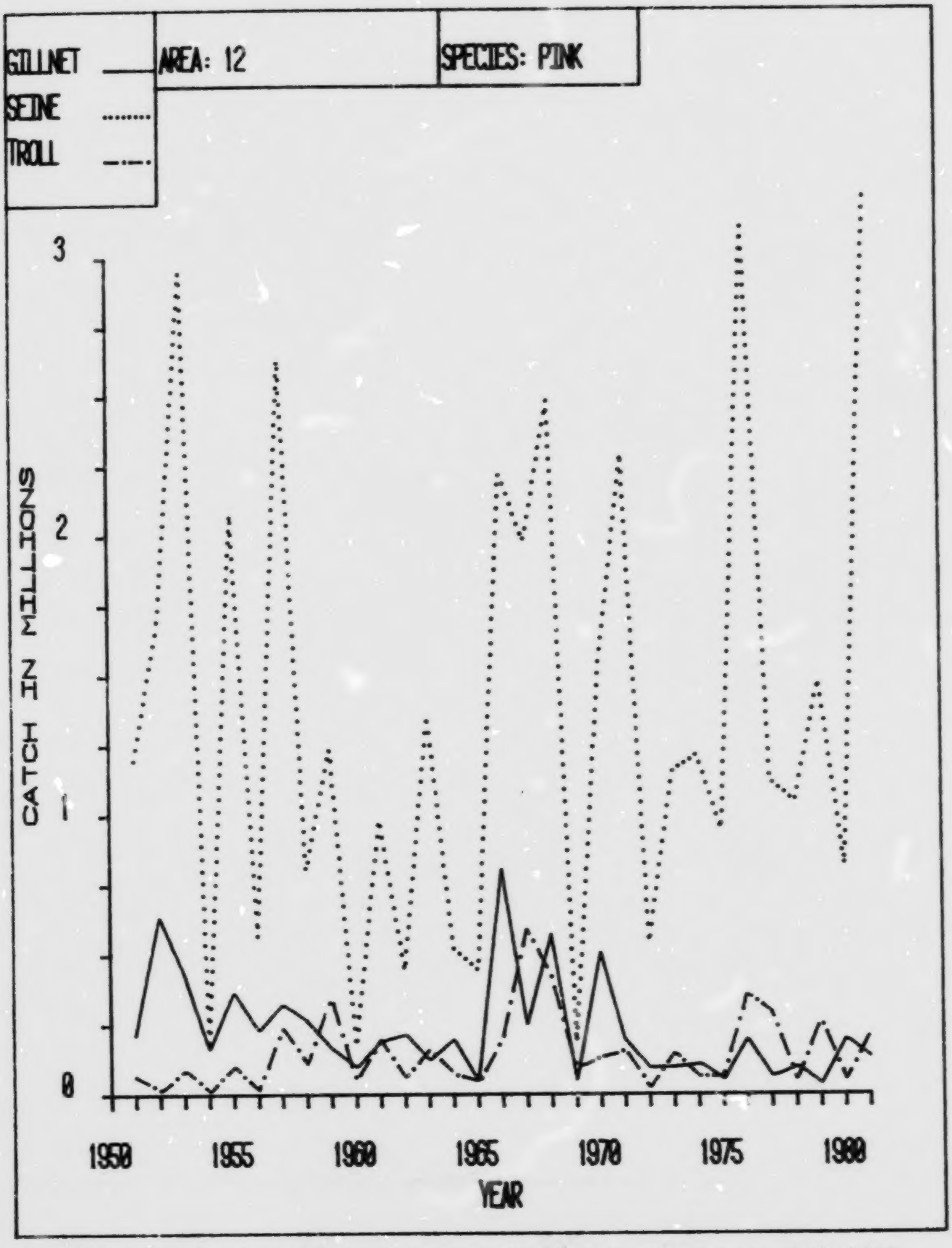

Fig. A12. Catch of pink salmon by gear in Statistical Area 12, 1951-1981.

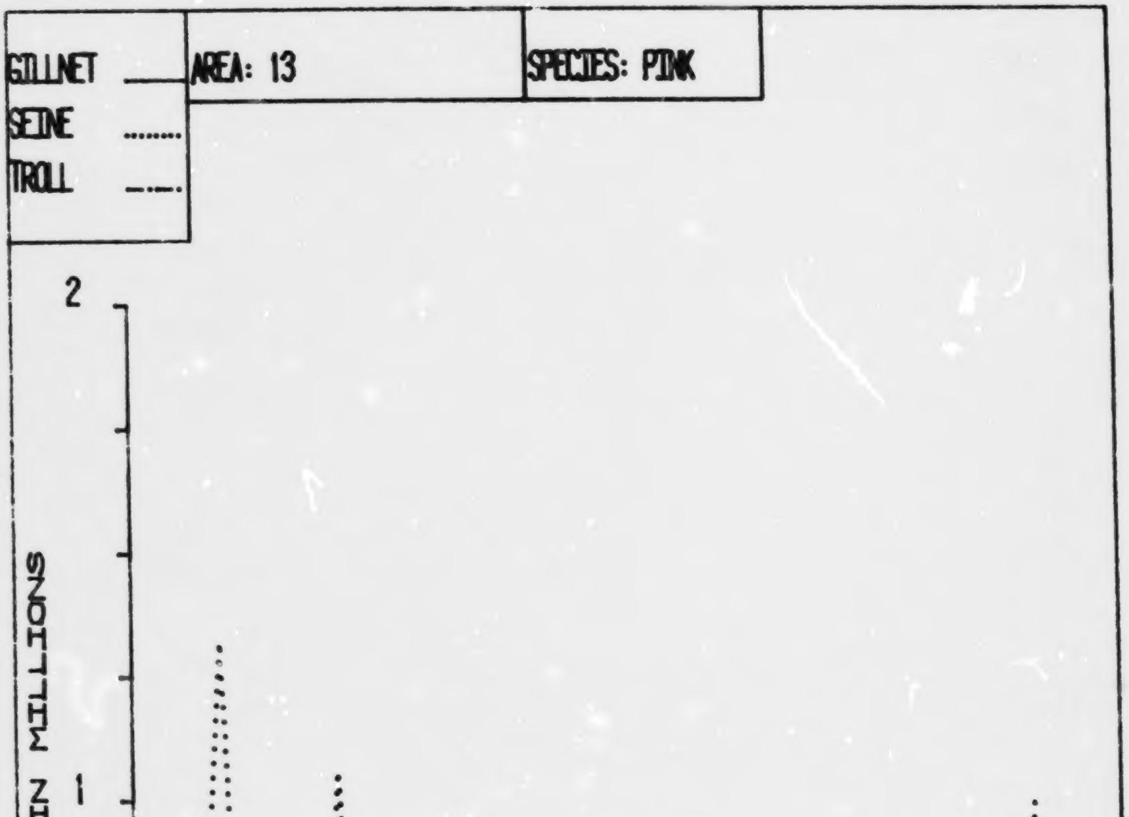

Fig. A13. Catch of pink salmon by gear in Statistical Area 13, 1951-1981.

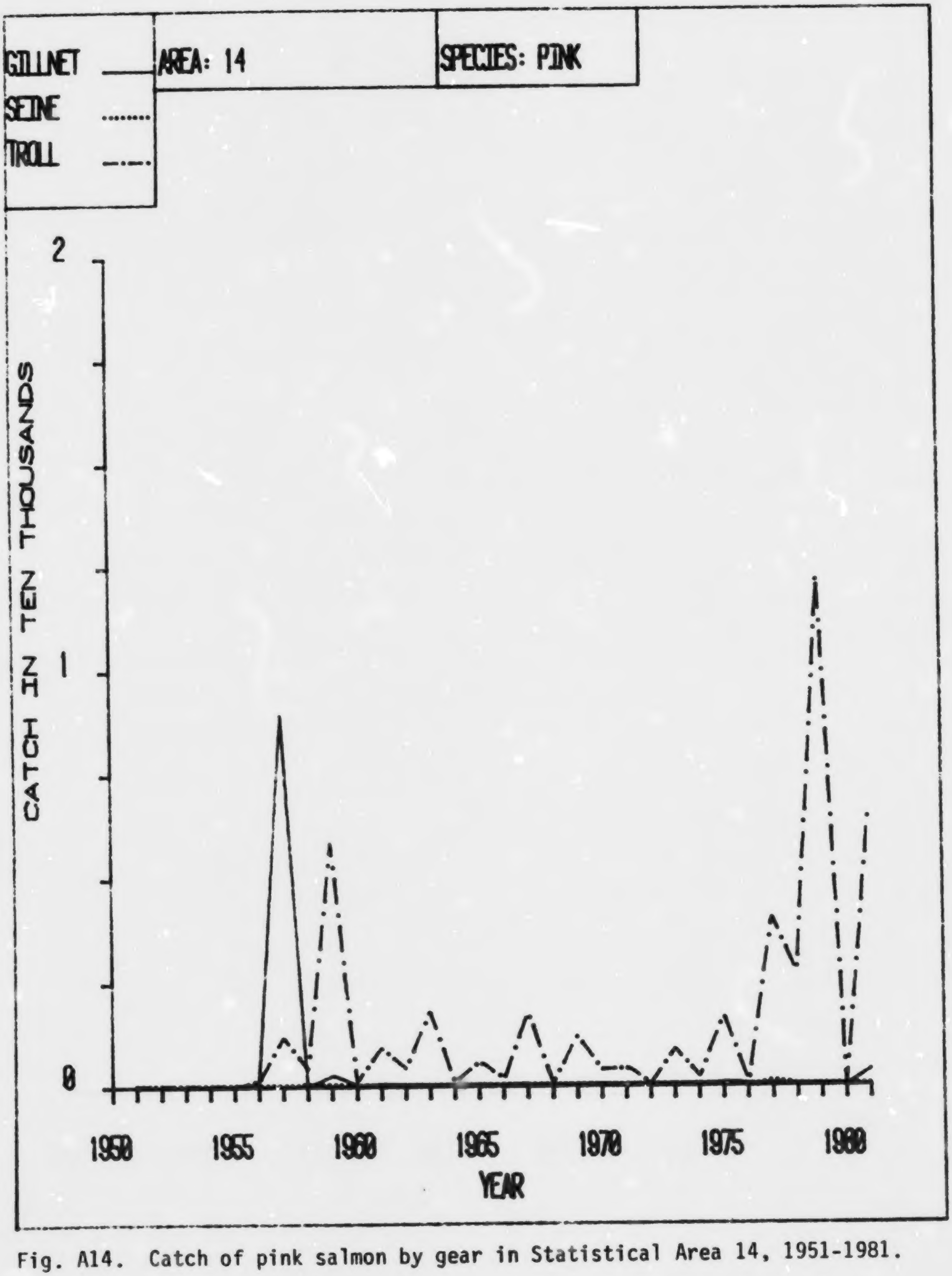

Fig. A14. Catch of pink salmon by gear in Statistical Area 14, 1951-1981.

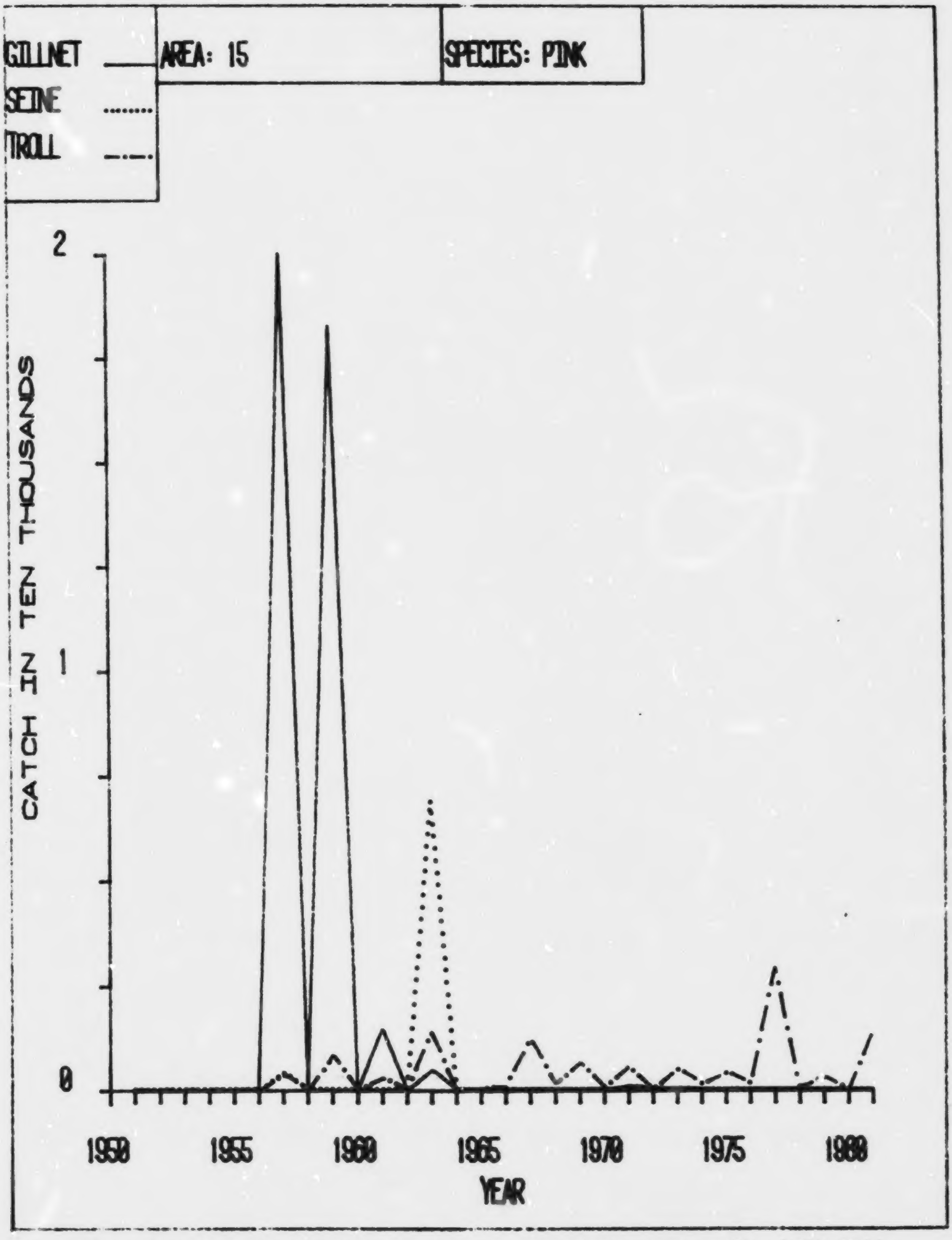

Fig. A15. Catch of pink salmon by gear in Statistical Area 15, 1951-1981.

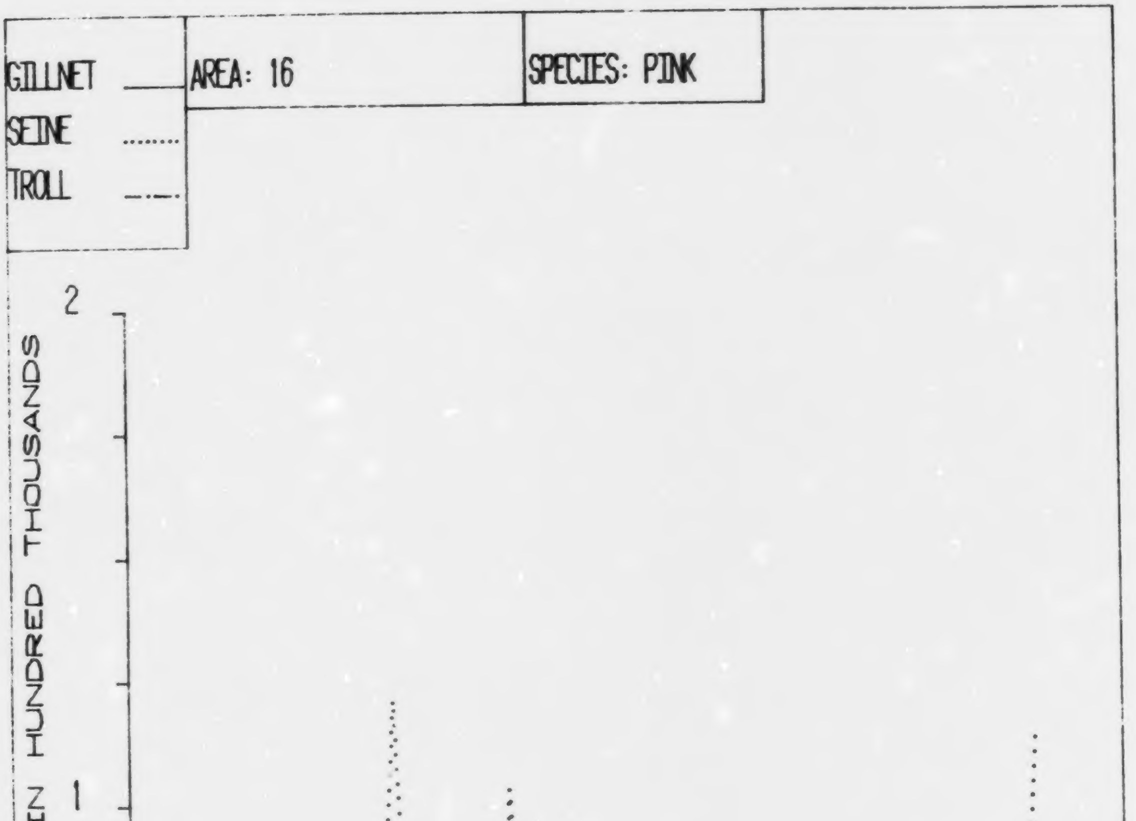

Fig. A16. Catch of pink salmon by gear in Statistical Area 16, 1951-1981.

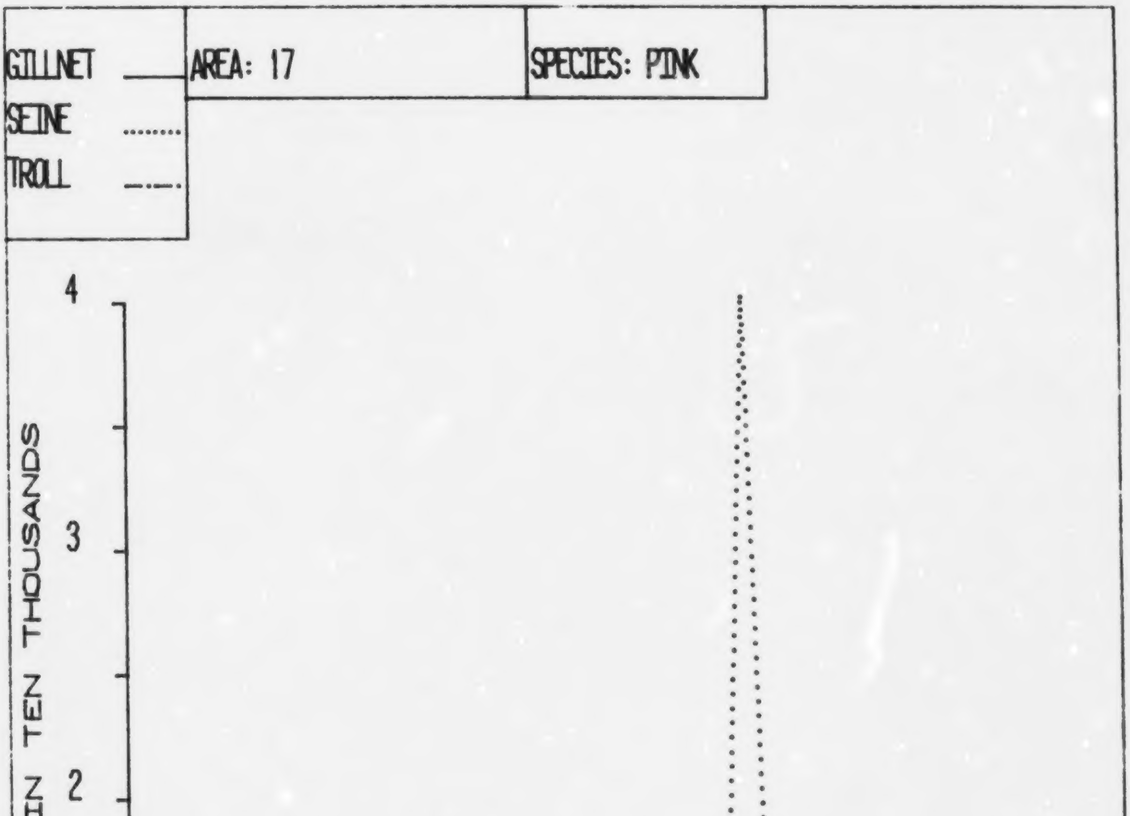

Fig. A17. Catch of pink salmon by gear in Statistical Area 17, 1951-1981.

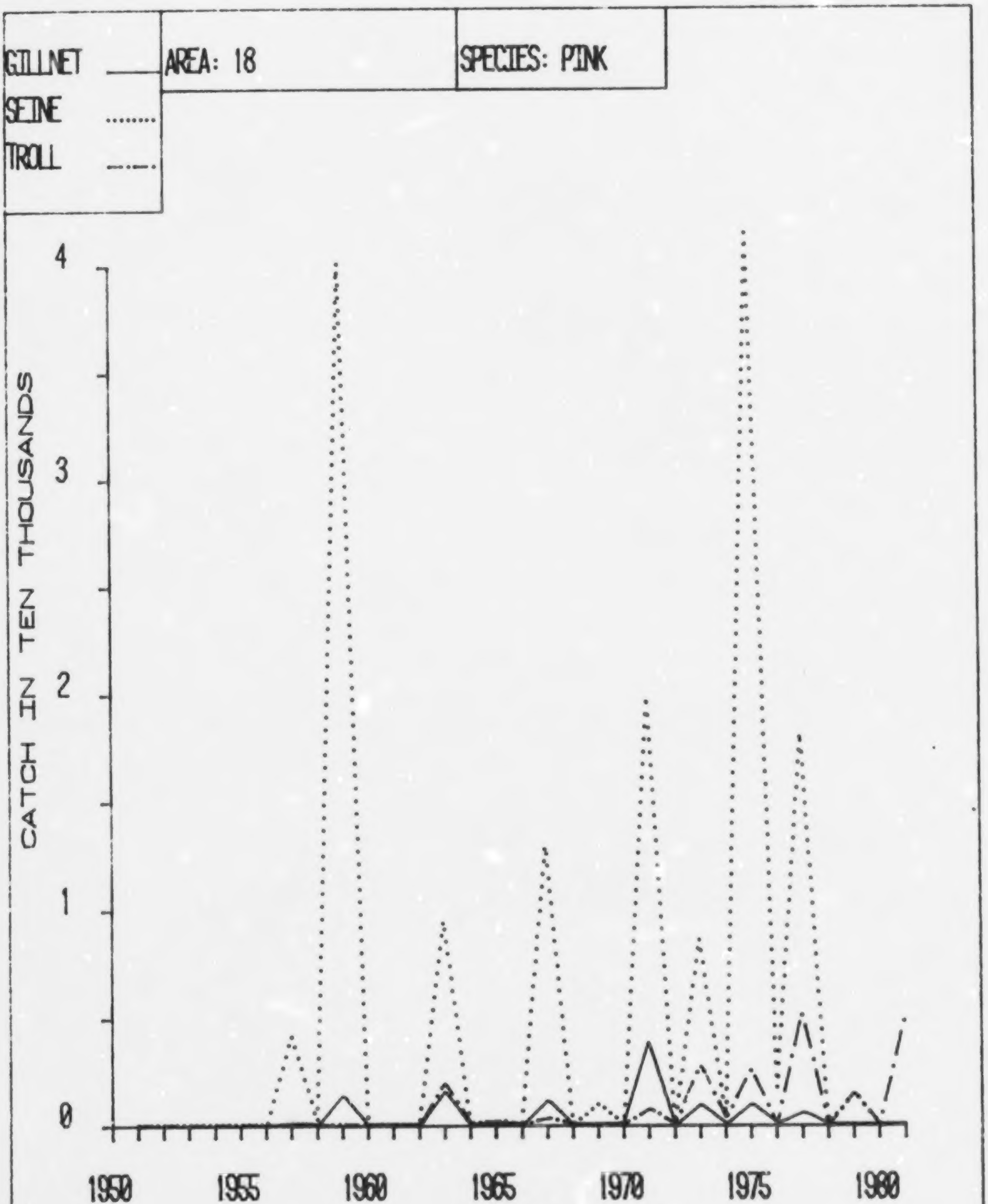

Fig. A18. Catch of pink salmon by gear in Statistical Area 18, 1951-1981.

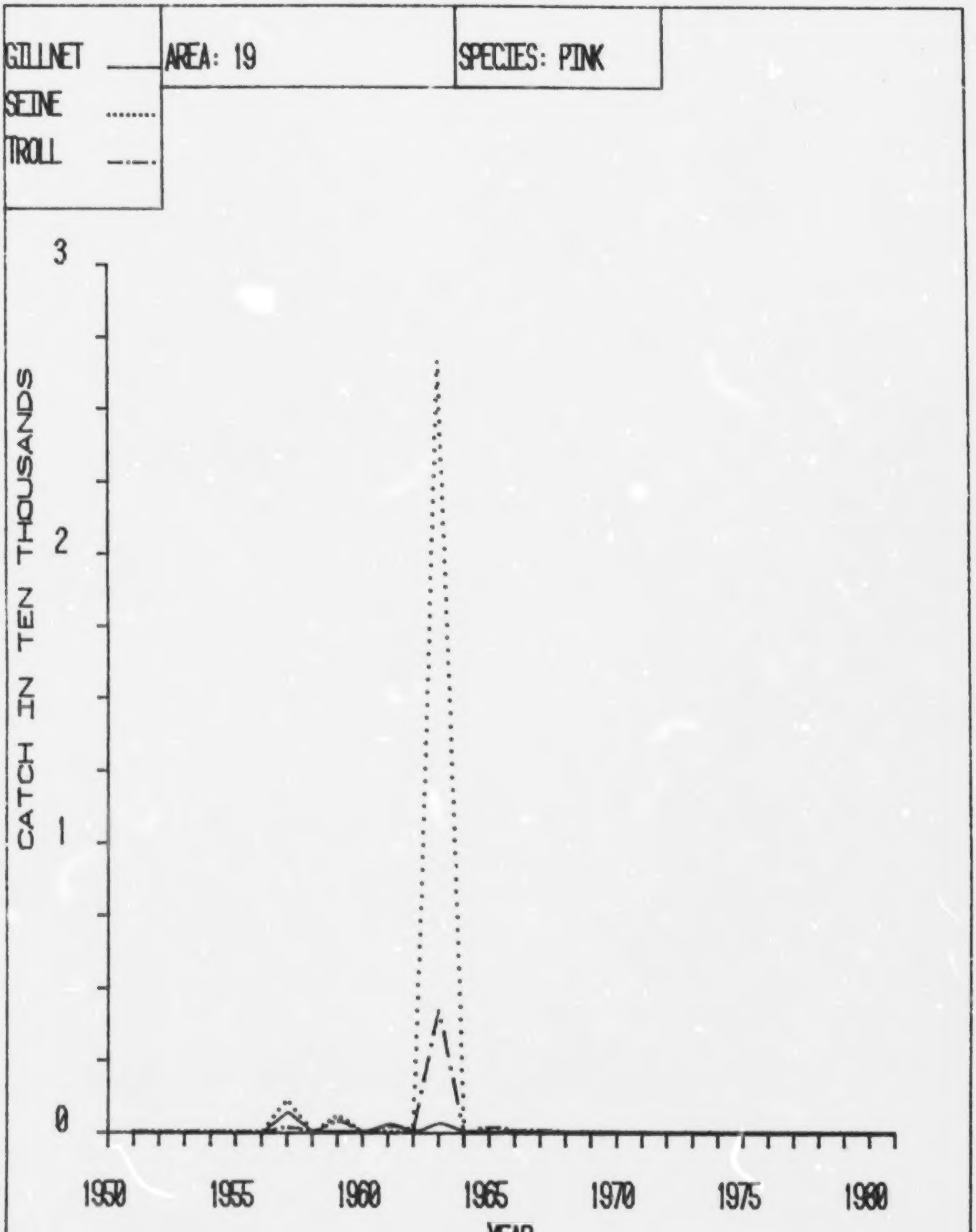

Fig. A19. Catch of pink salmon by gear in Statistical Area 19, 1951-1981.

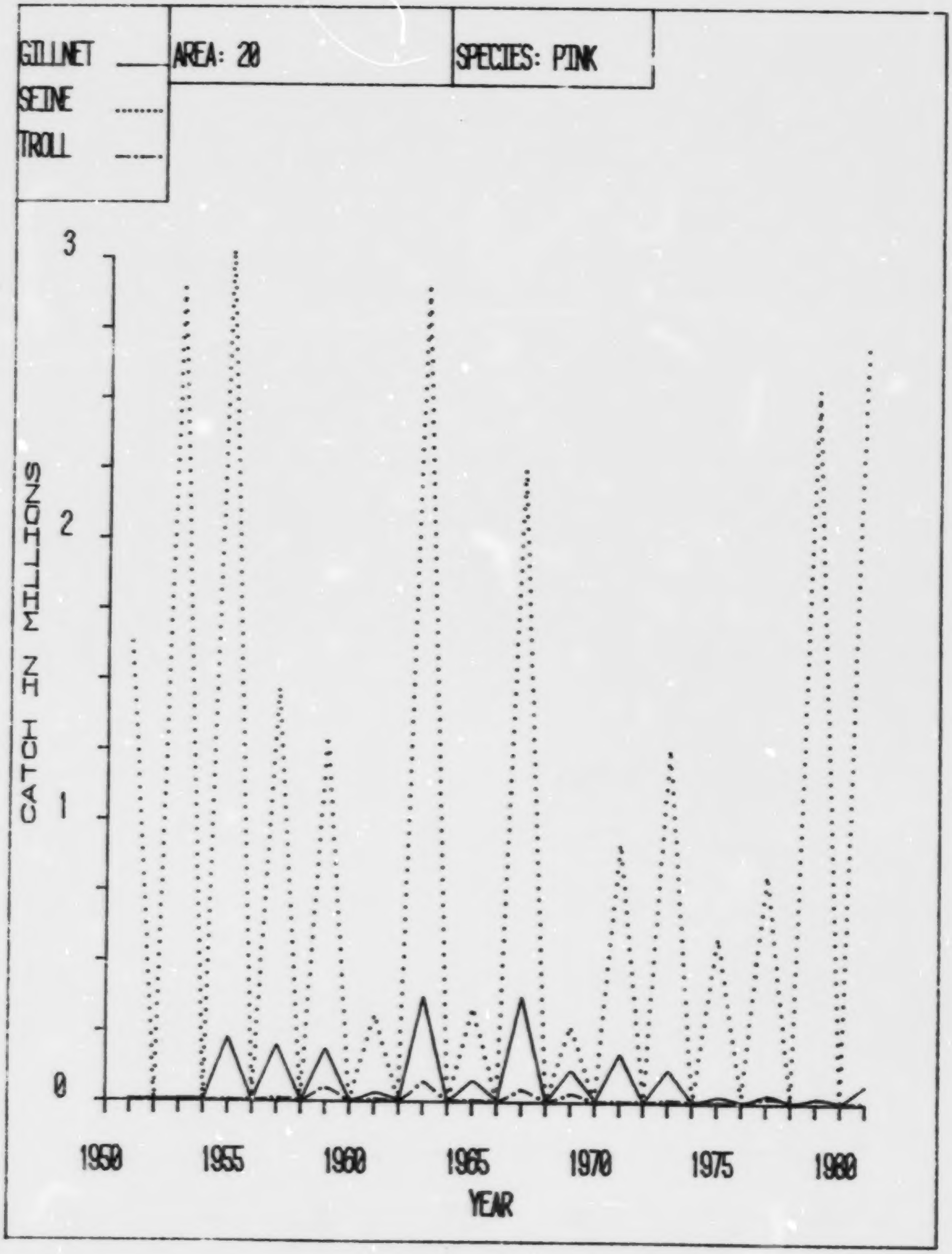

Fig. A20. Catch of pink salmon by gear in Statistical Area 20, 1951-1981.

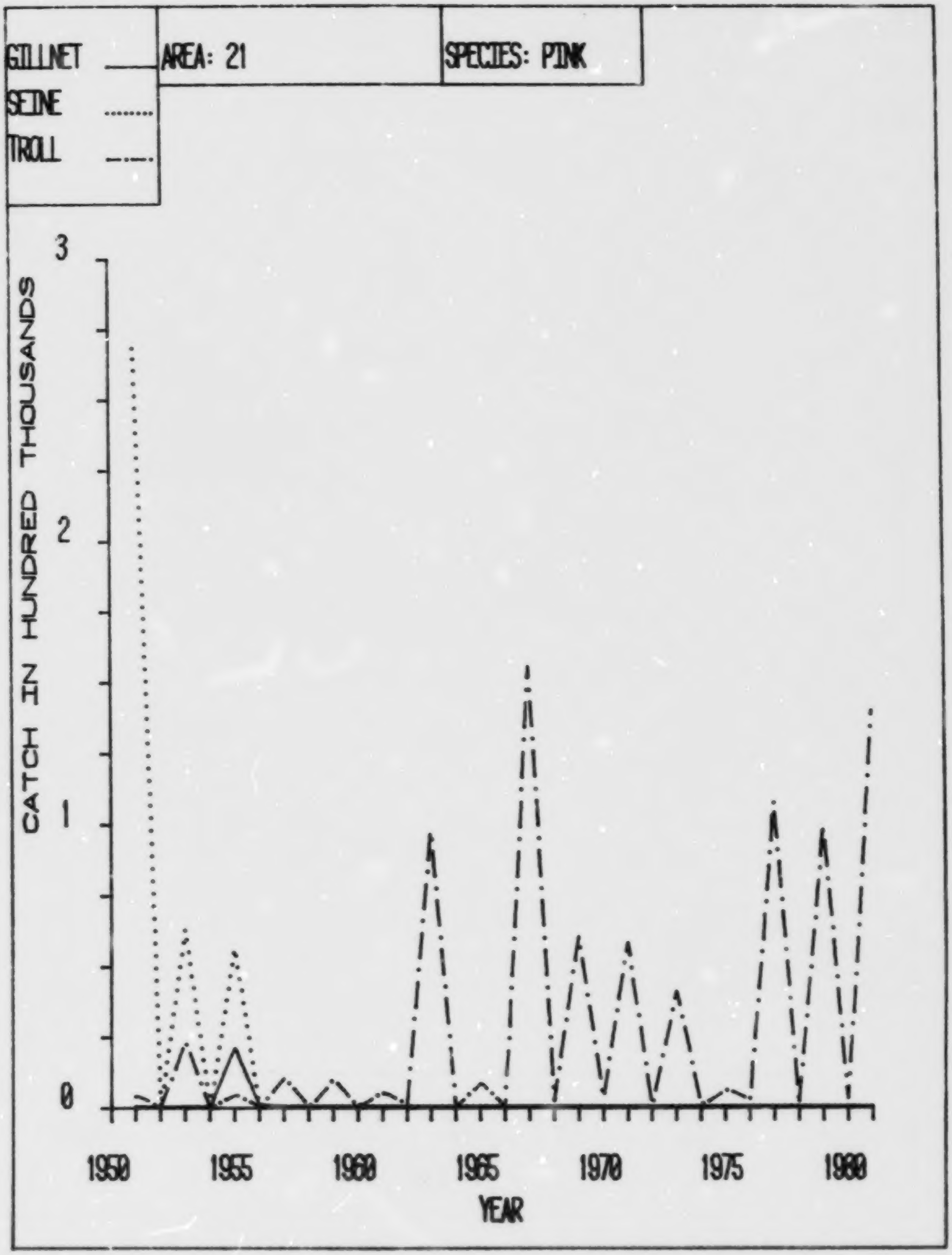

Fig. A21. Catch of pink salmon by gear in Statistical Area 21, 1951-1981.

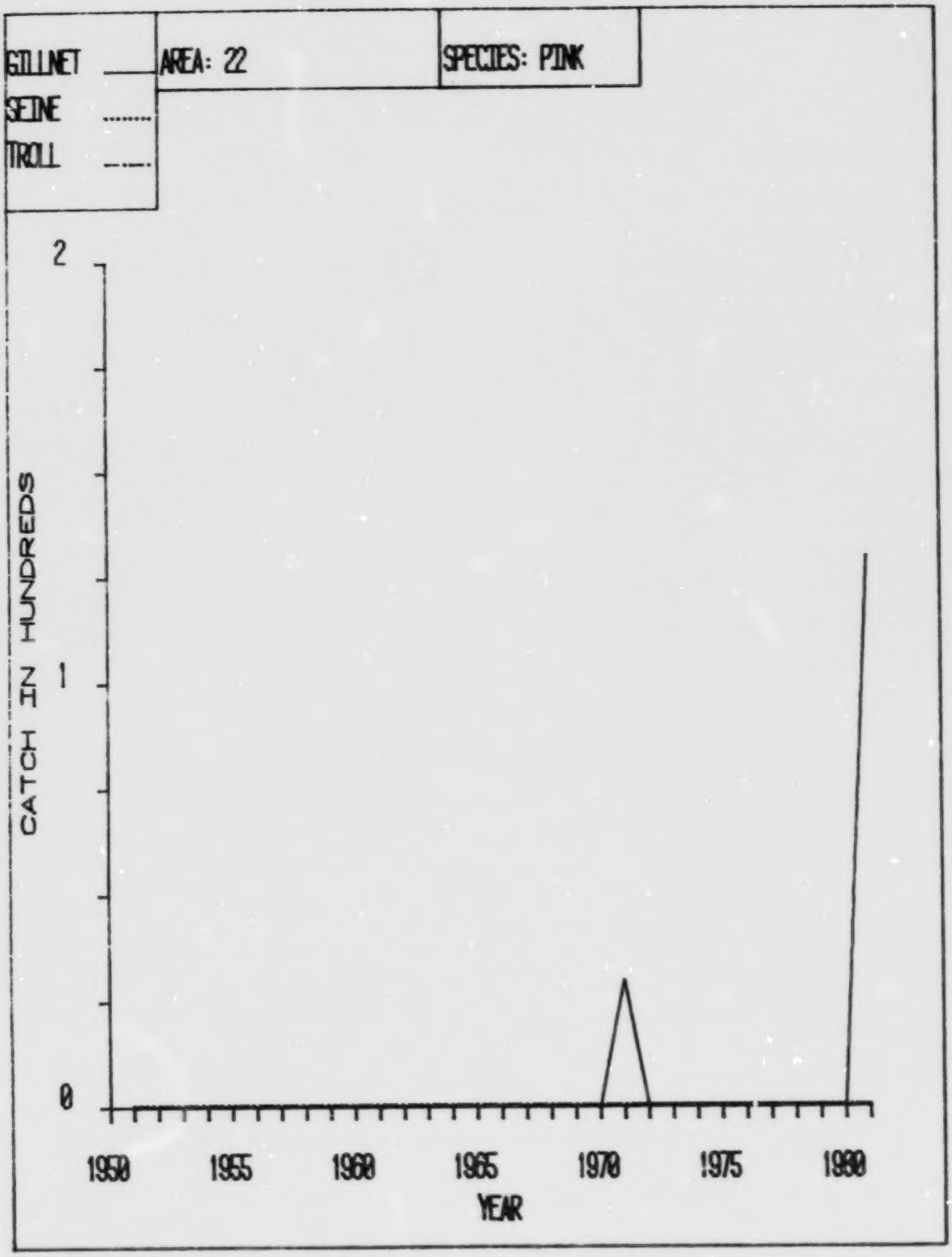

Fig. A22. Catch of pink salmon by gear in Statistical Area 22, 1951-1981.

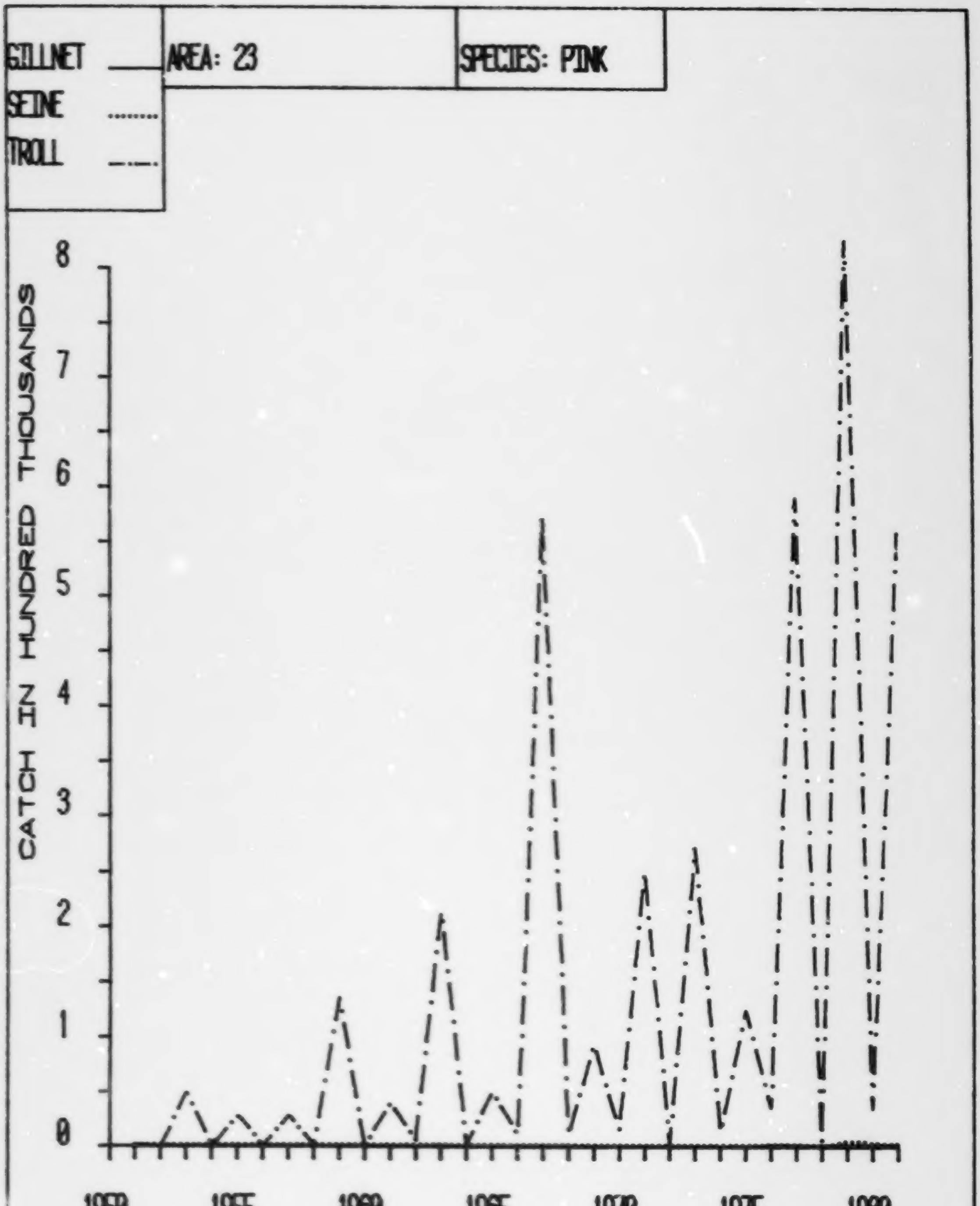

Fig. A23. Catch of pink salmon by gear in Statistical Area 23, 1951-1981.

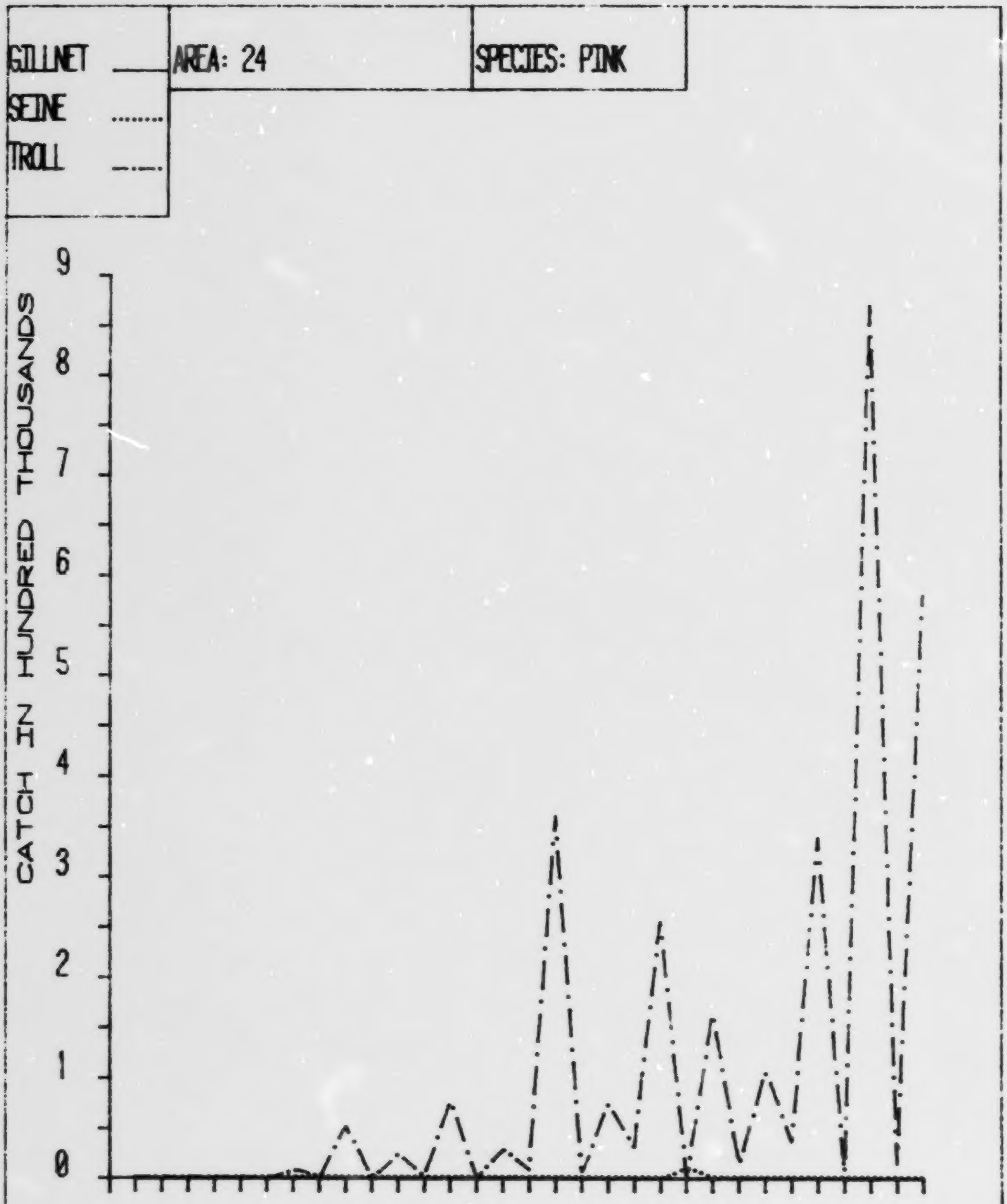

Fig. A24. Catch of pink salmon by gear in Statistical Area 24. 1951-1981.

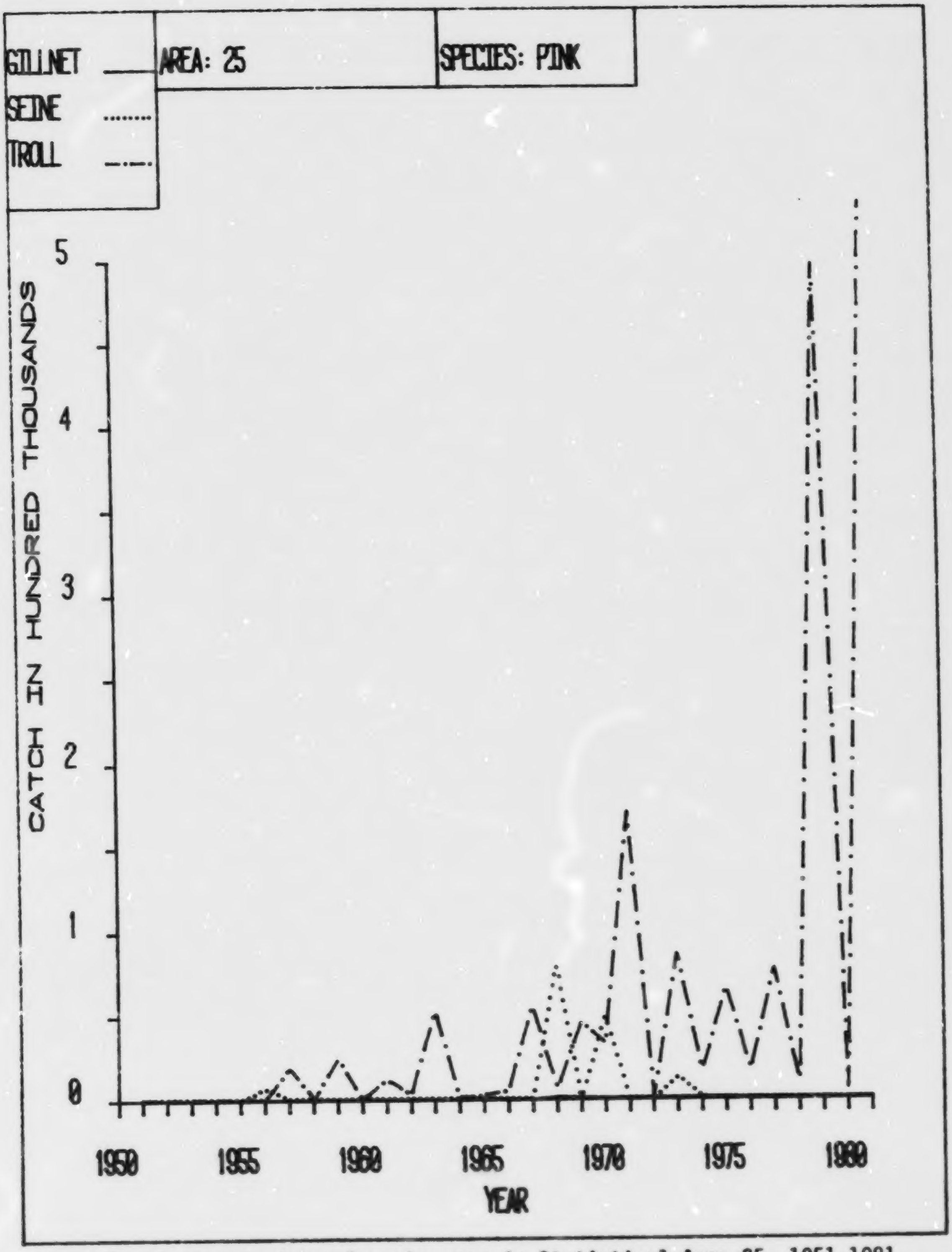

Fig. A25. Catch of pink salmon by gear in Statistical Area 25, 1951-1981.

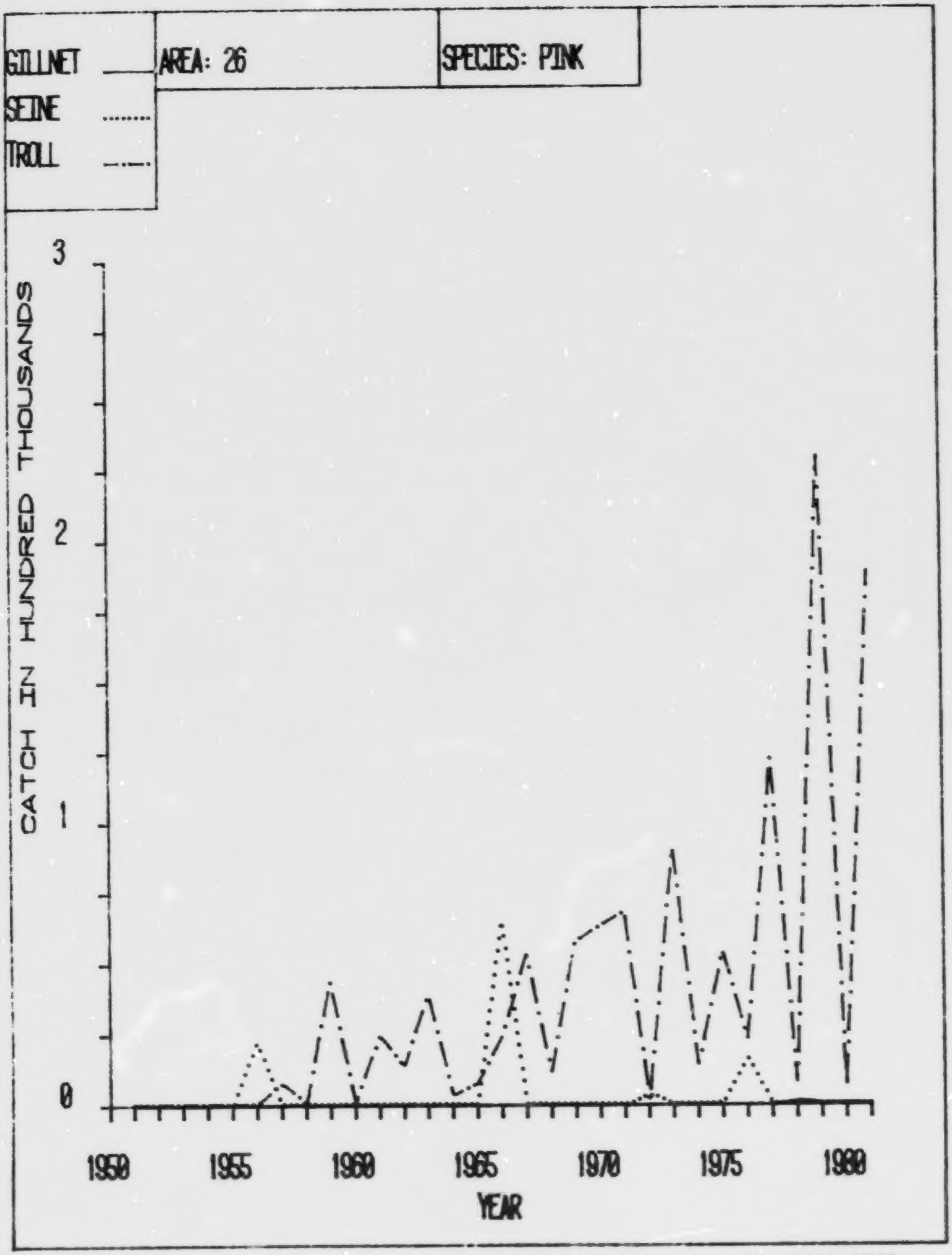

Fig. A26. Catch of pink salmon by gear in Statistical Area 26, 1951-1981.

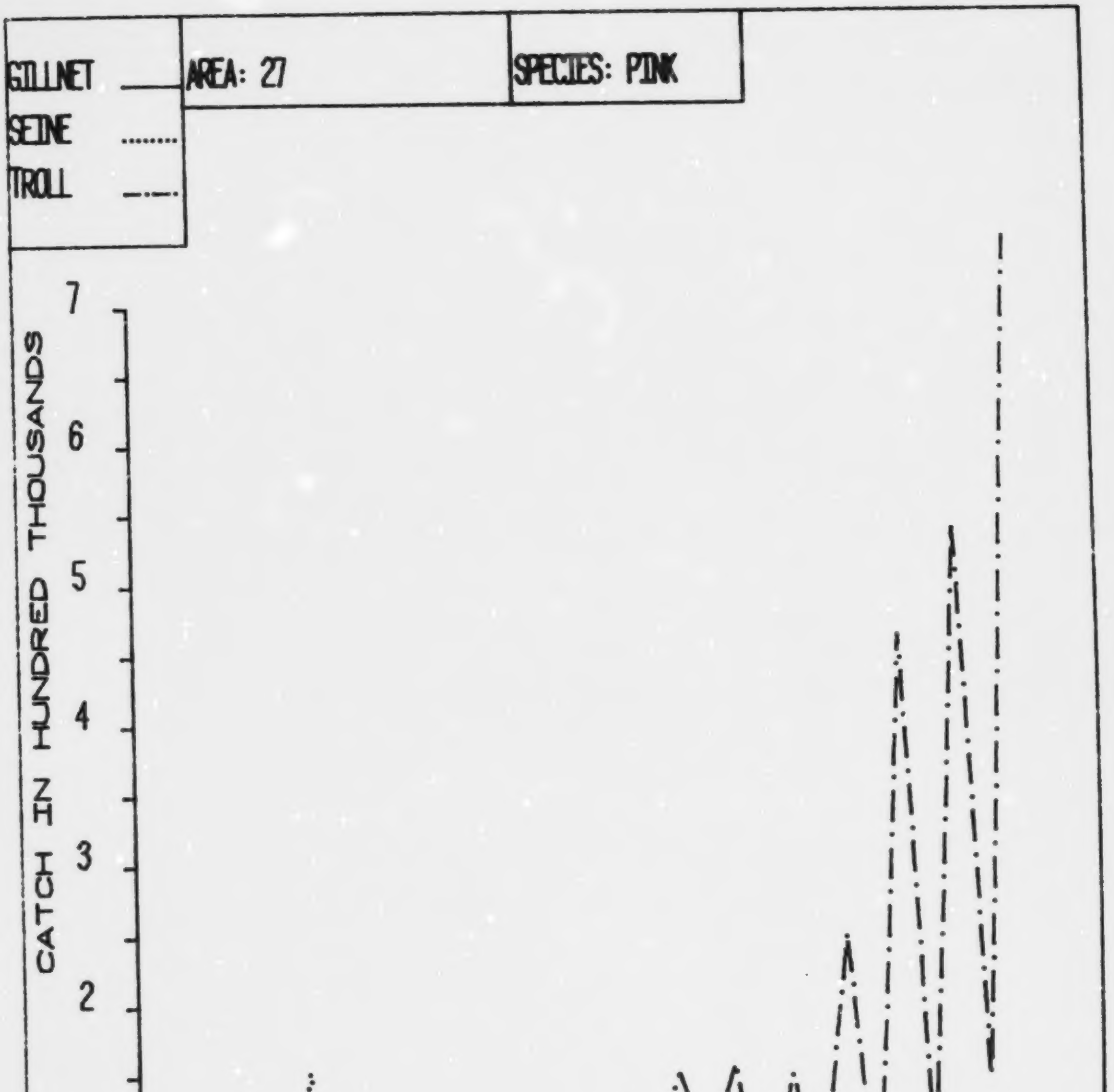

Fig. A27. Catch of pink salmon by gear in Statistical Area 27, 1951-1981.

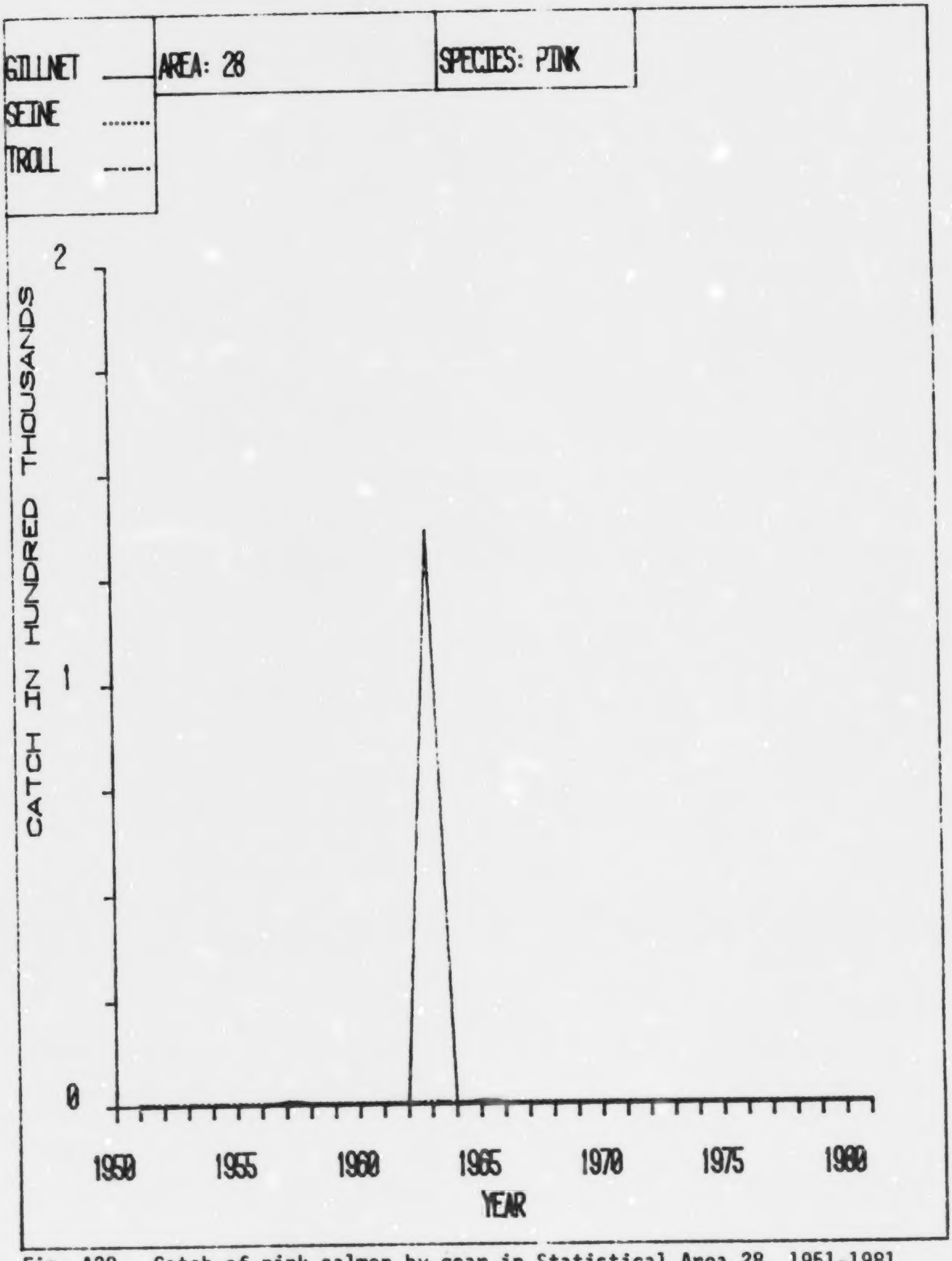

Fig. A28. Catch of pink salmon by gear in Statistical Area 28, 1951-1981.

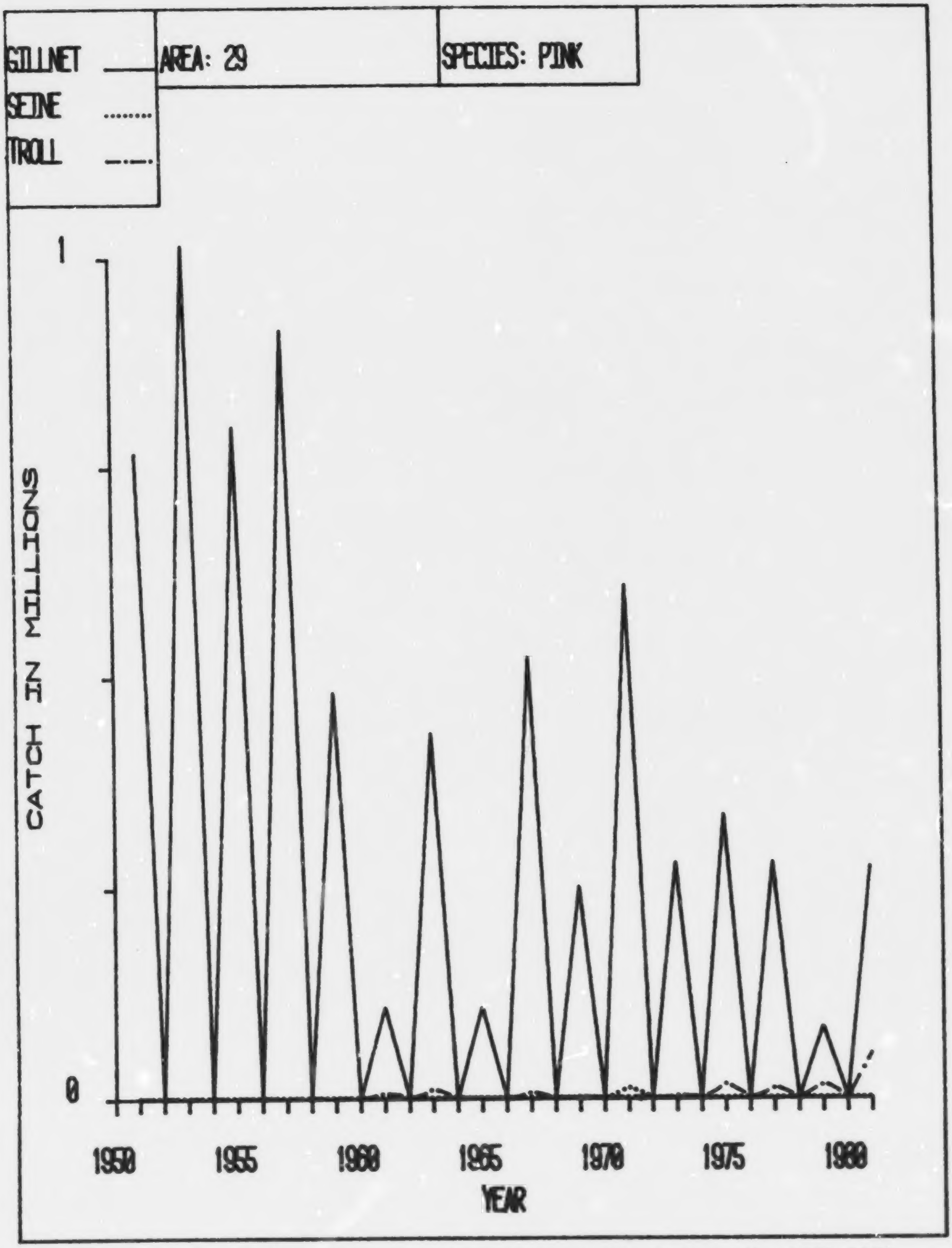

Fig. A29. Catch of pink salmon by gear in Statistical Area 29, 1951-1981.

APPENDIX B

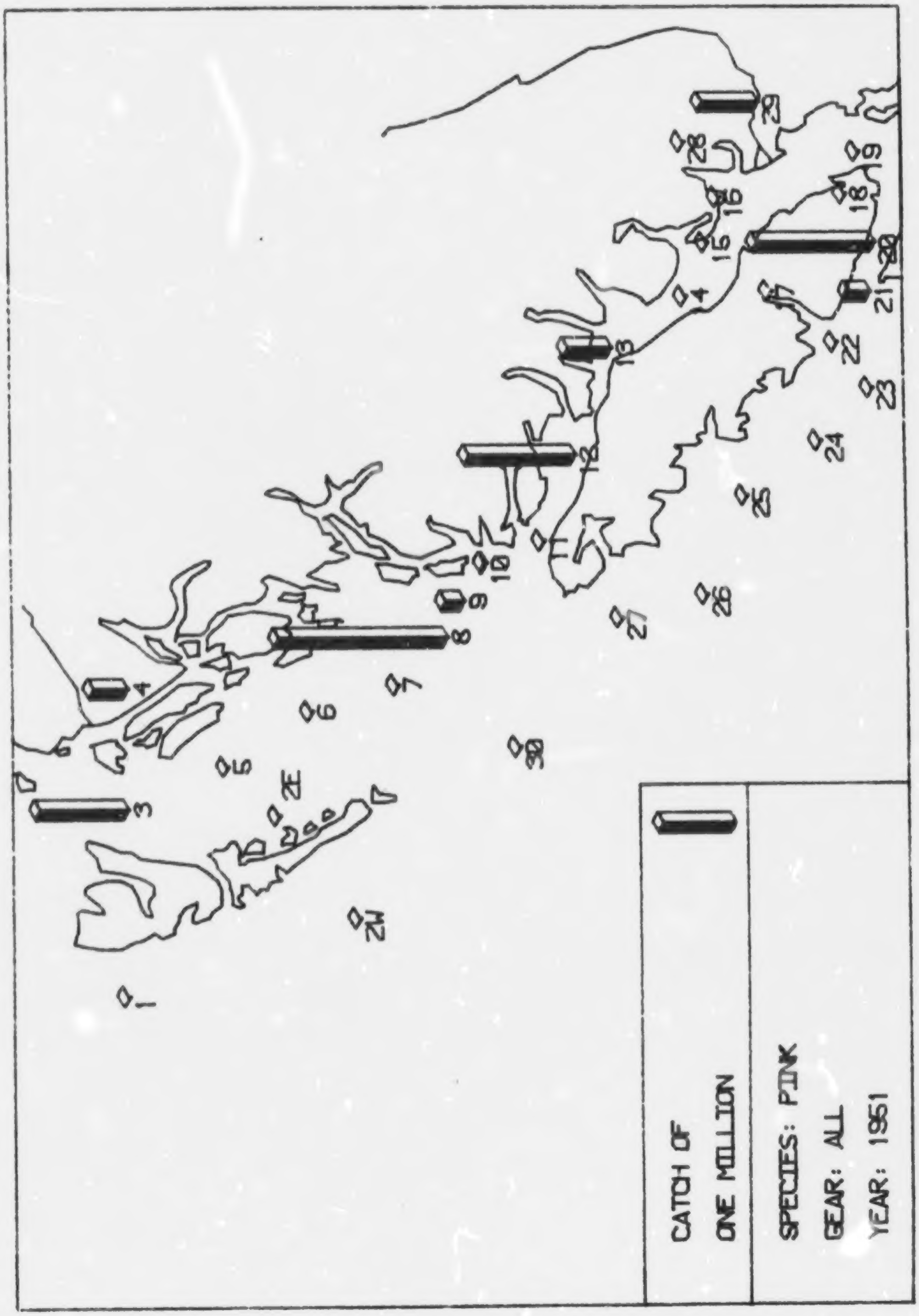
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1951
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B1. Catch of pink salmon by statistical area in 1951.

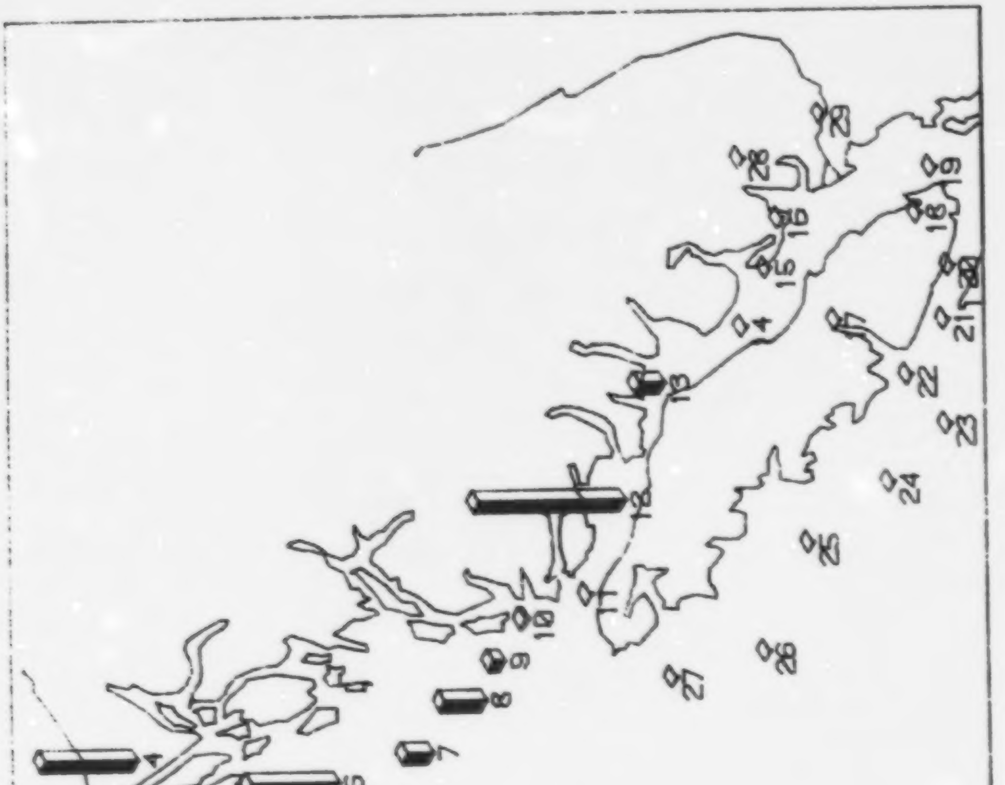
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1952
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
18
19
21
22
23
24
25
26
27
28
30

Fig. B2. Catch of pink salmon by statistical area in 1952.

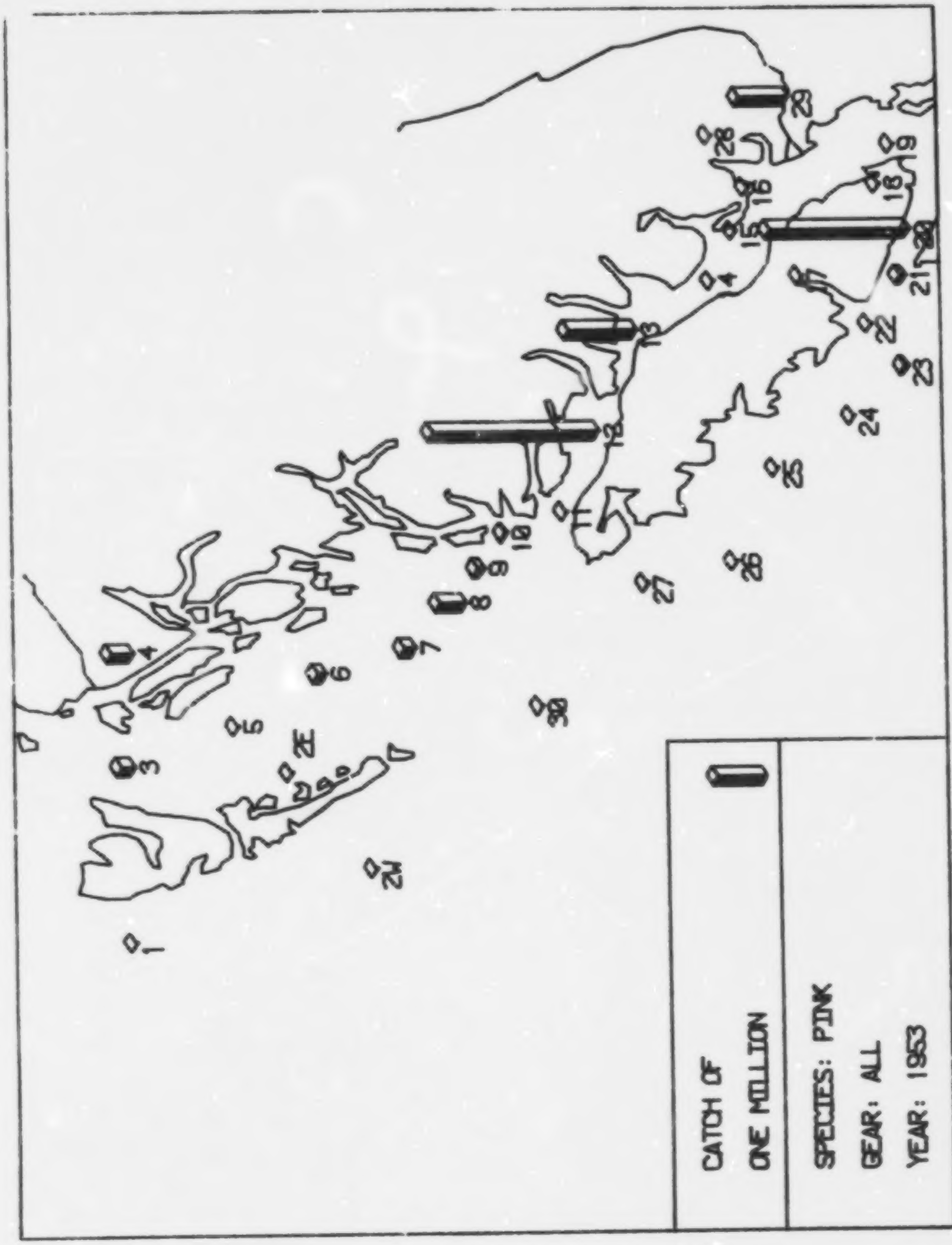
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1953

Fig. B3. Catch of pink salmon by statistical area in 1953.

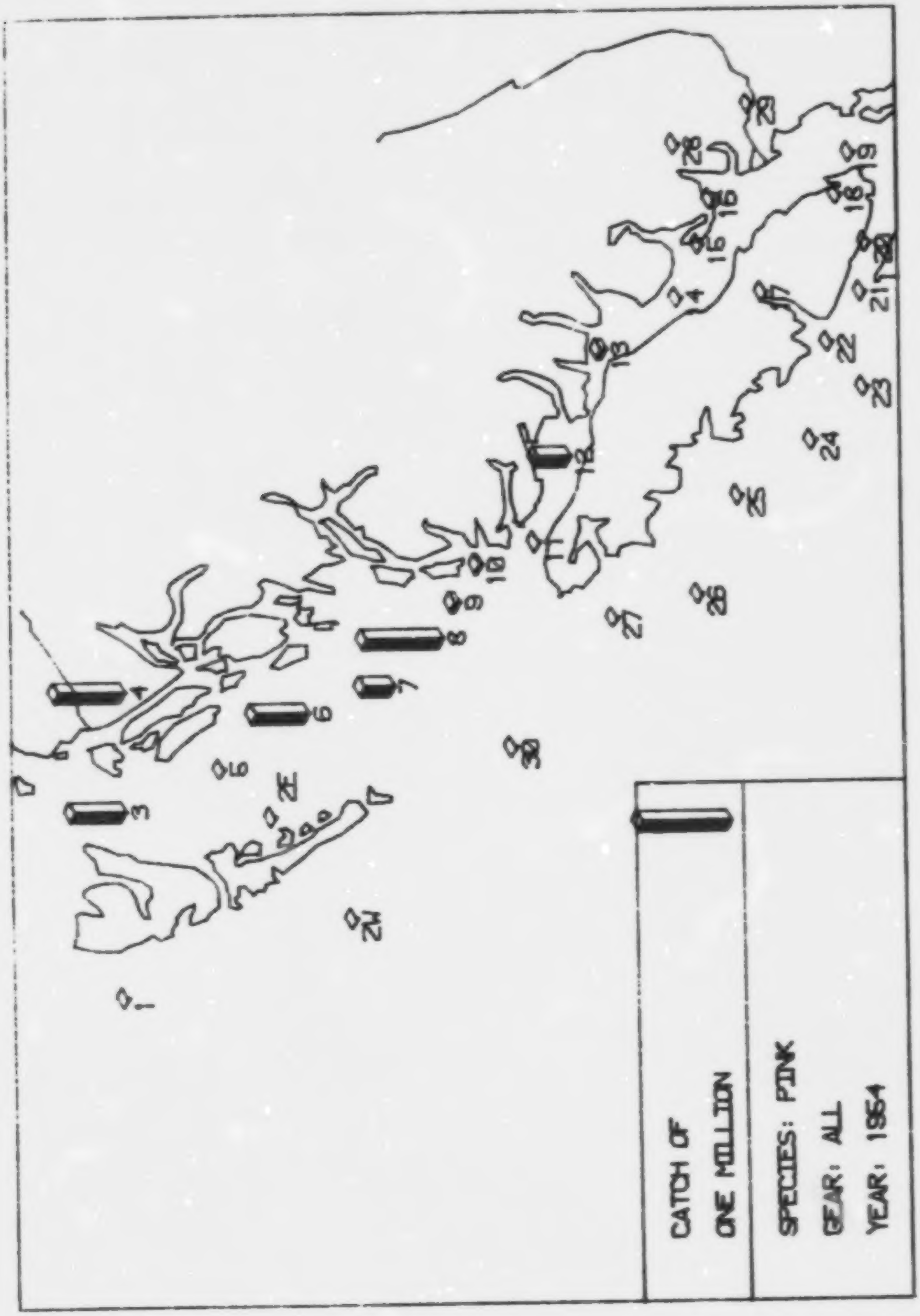
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1954

Fig. B4. Catch of pink salmon by statistical area in 1954.

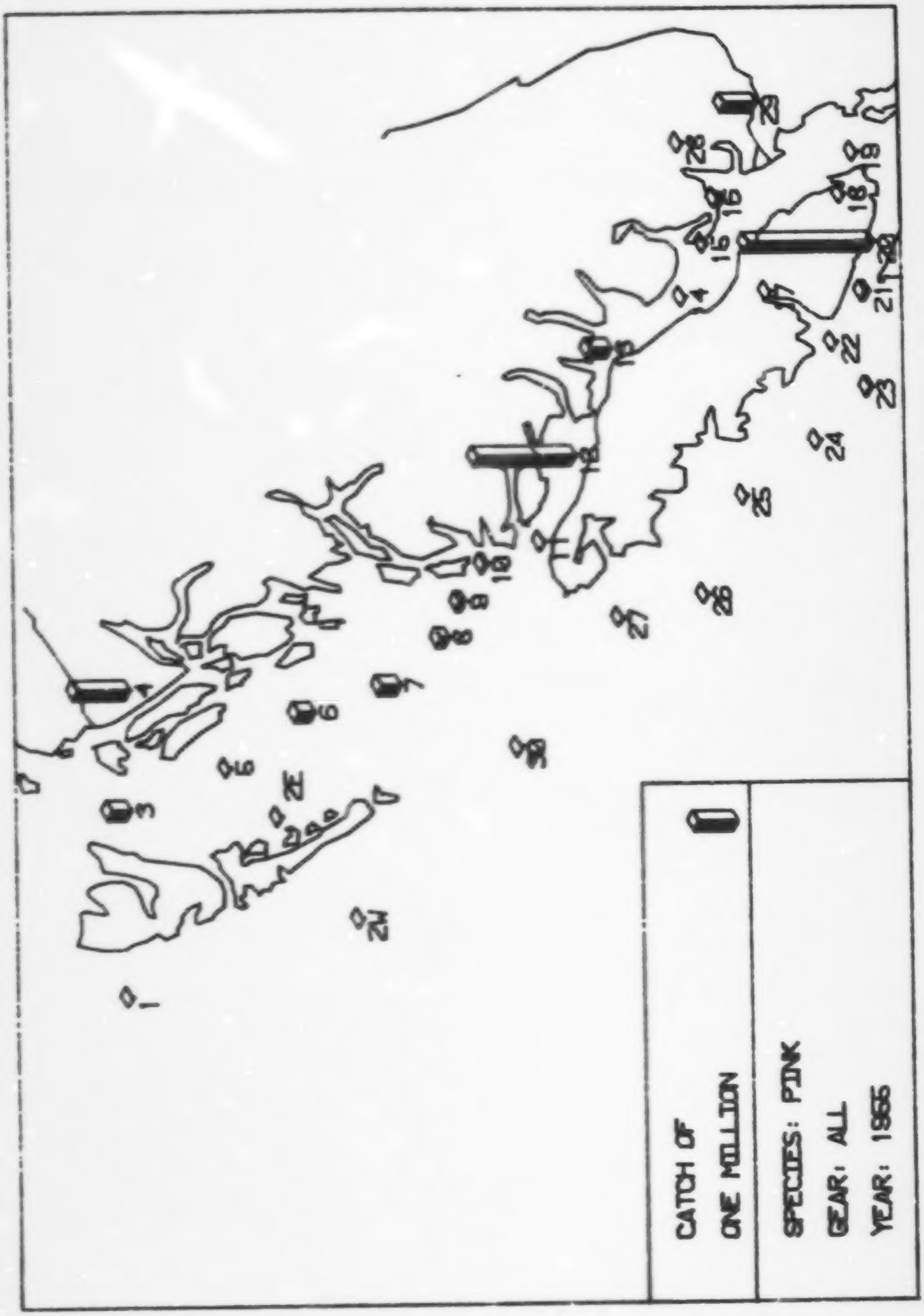
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1955
29
28
16
15
19
18
20
21
17
14
13
22
23
24
12
25
11
26
10
27
9
8
7
6
5
4
3
2
1

Fig. B5. Catch of pink salmon by statistical area in 1955.

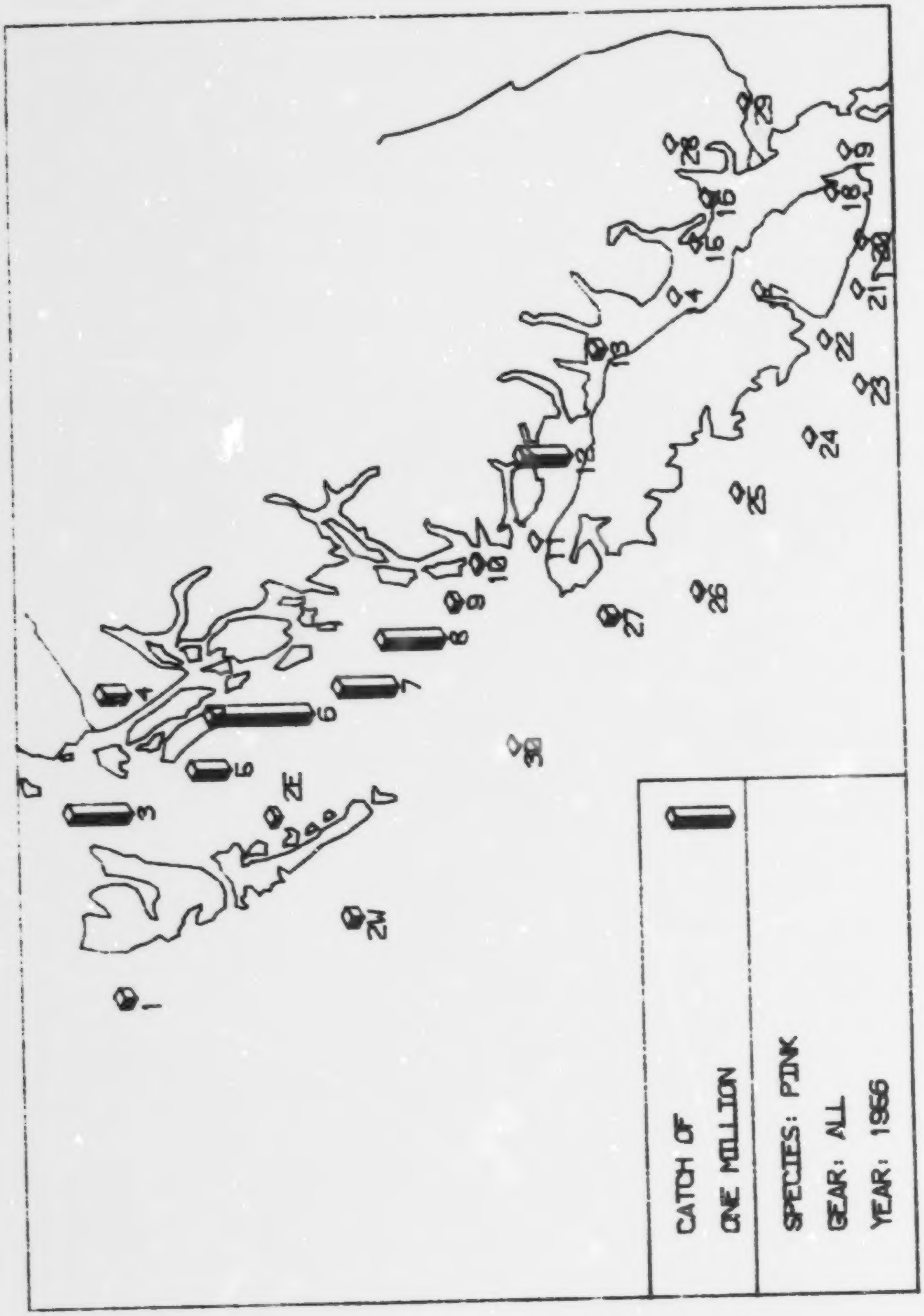
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1956
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B6. Catch of pink salmon by statistical area in 1956.

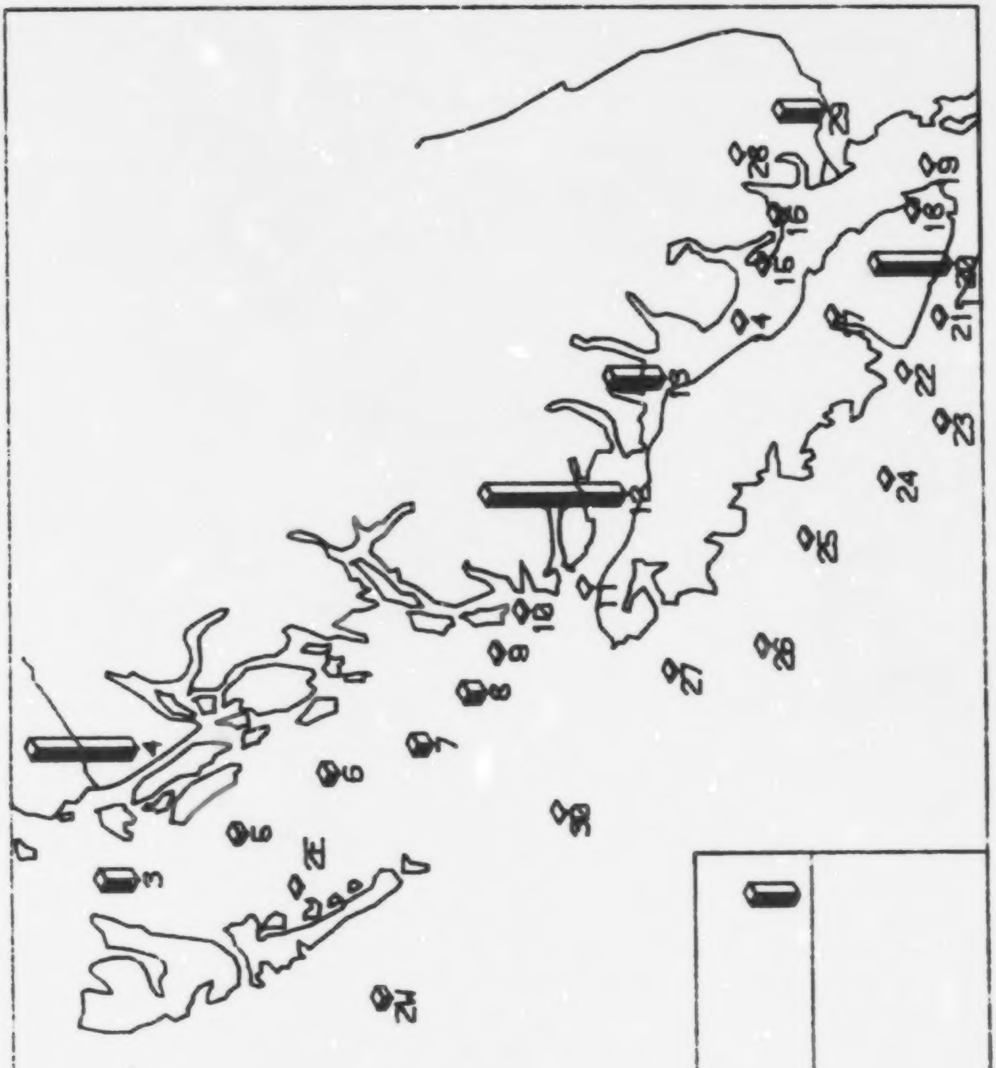
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1957

Fig. B7. Catch of pink salmon by statistical area in 1957.

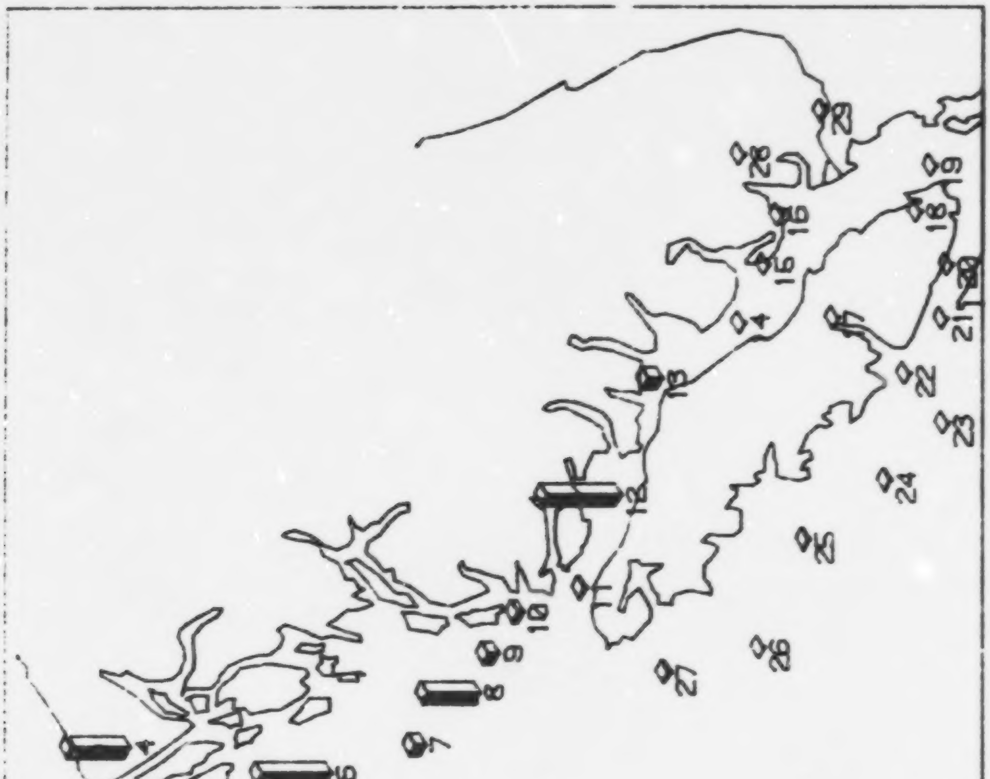
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1958
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B8. Catch of pink salmon by statistical area in 1958.

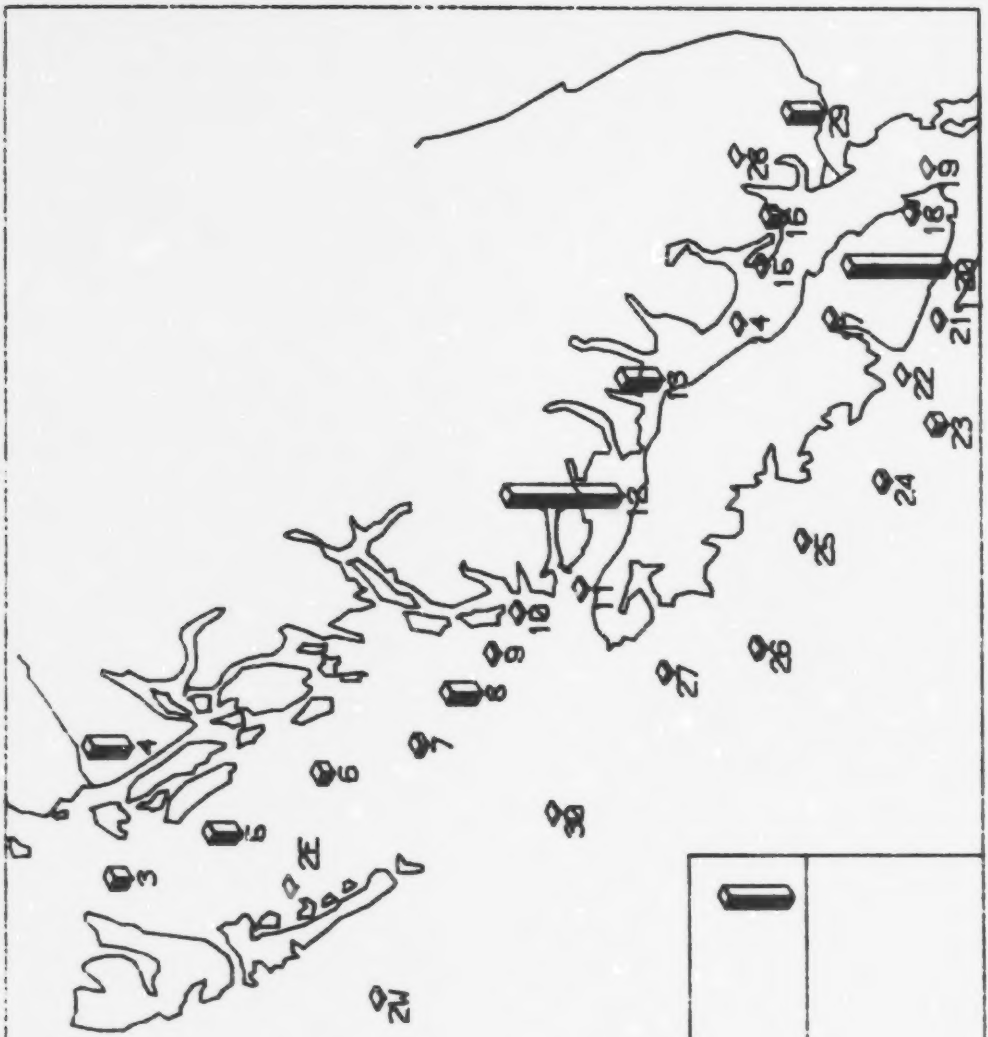
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1959

Fig. B9. Catch of pink salmon by statistical area in 1959.

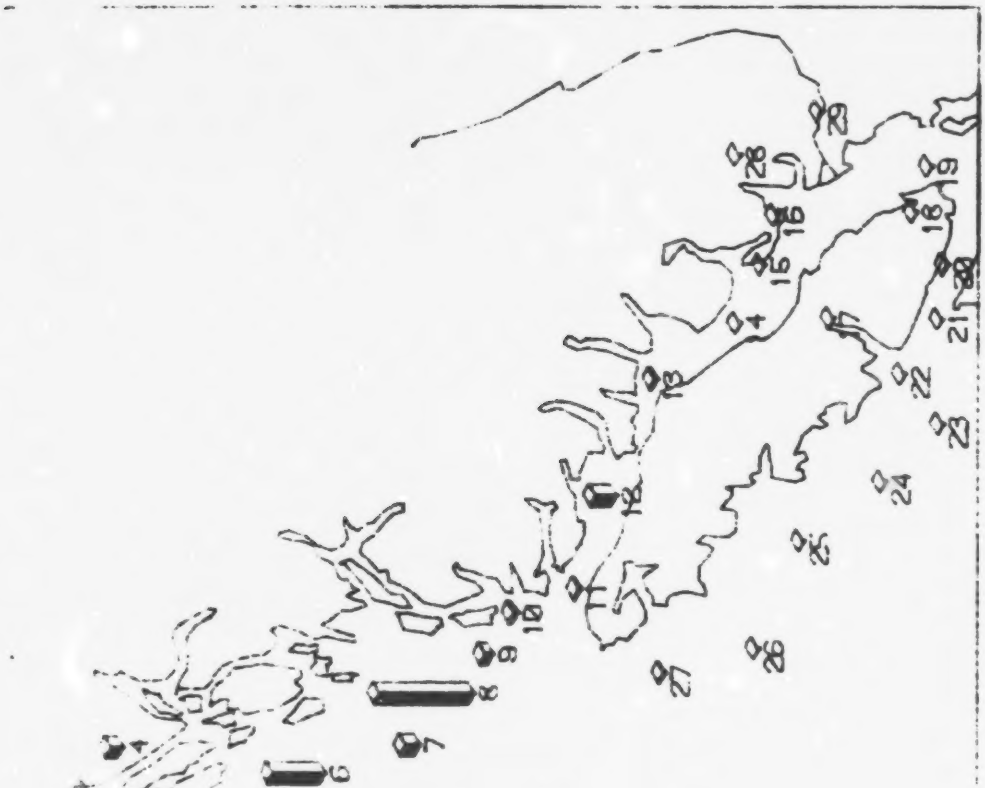
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1960

Fig. B10. Catch of pink salmon by statistical area in 1960.

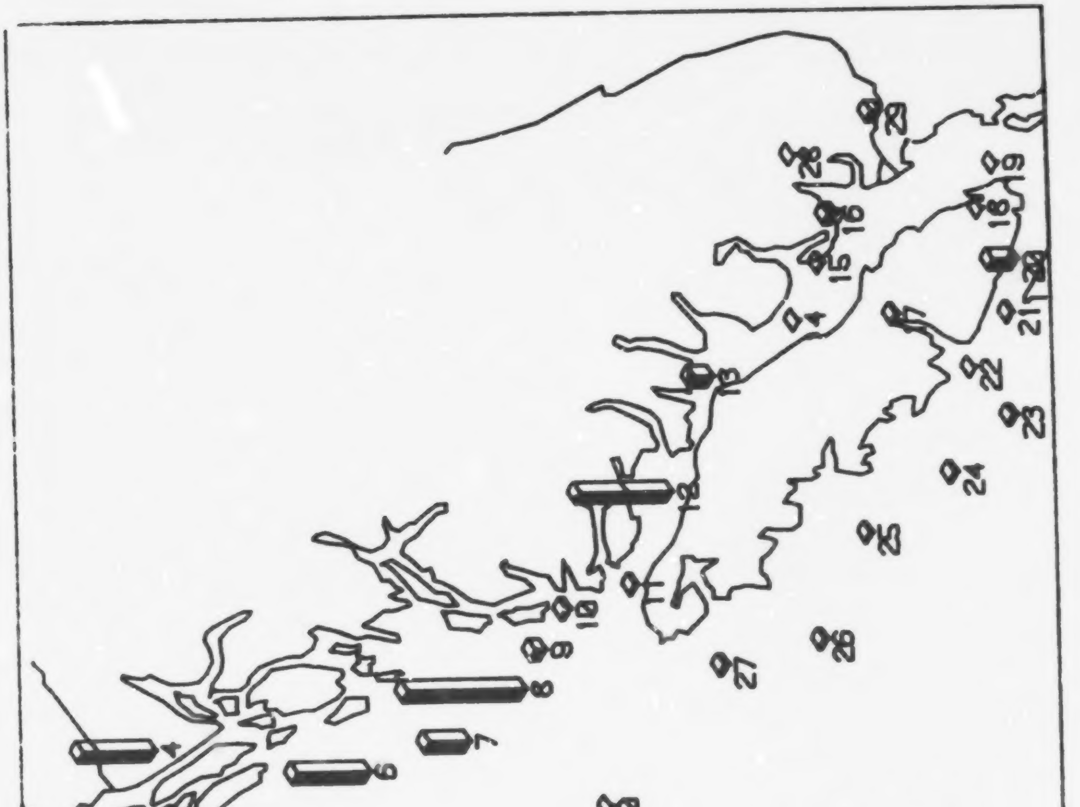
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1961

Fig. B11. Catch of pink salmon by statistical area in 1961.

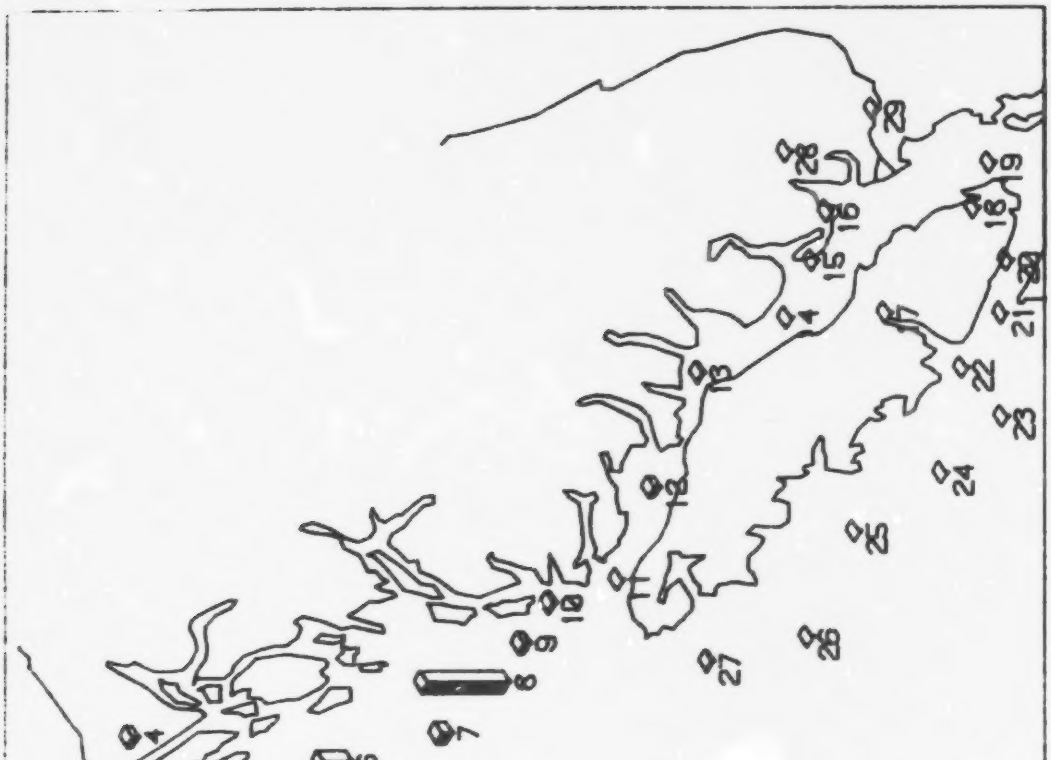
CATCH OF
TEN MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1962

Fig. B12. Catch of pink salmon by statistical area in 1962.

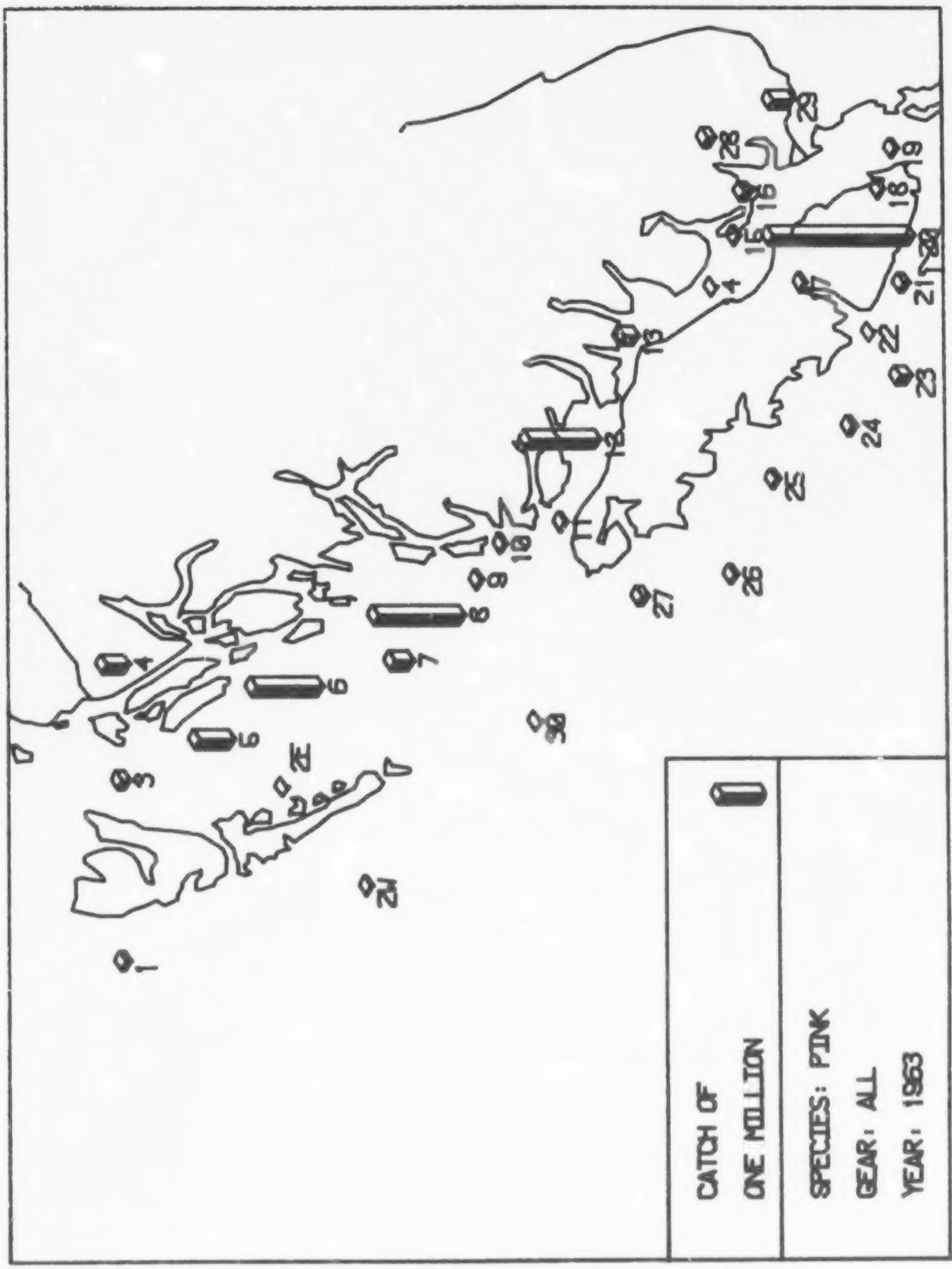
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1963

Fig. B13. Catch of pink salmon by statistical area in 1963.

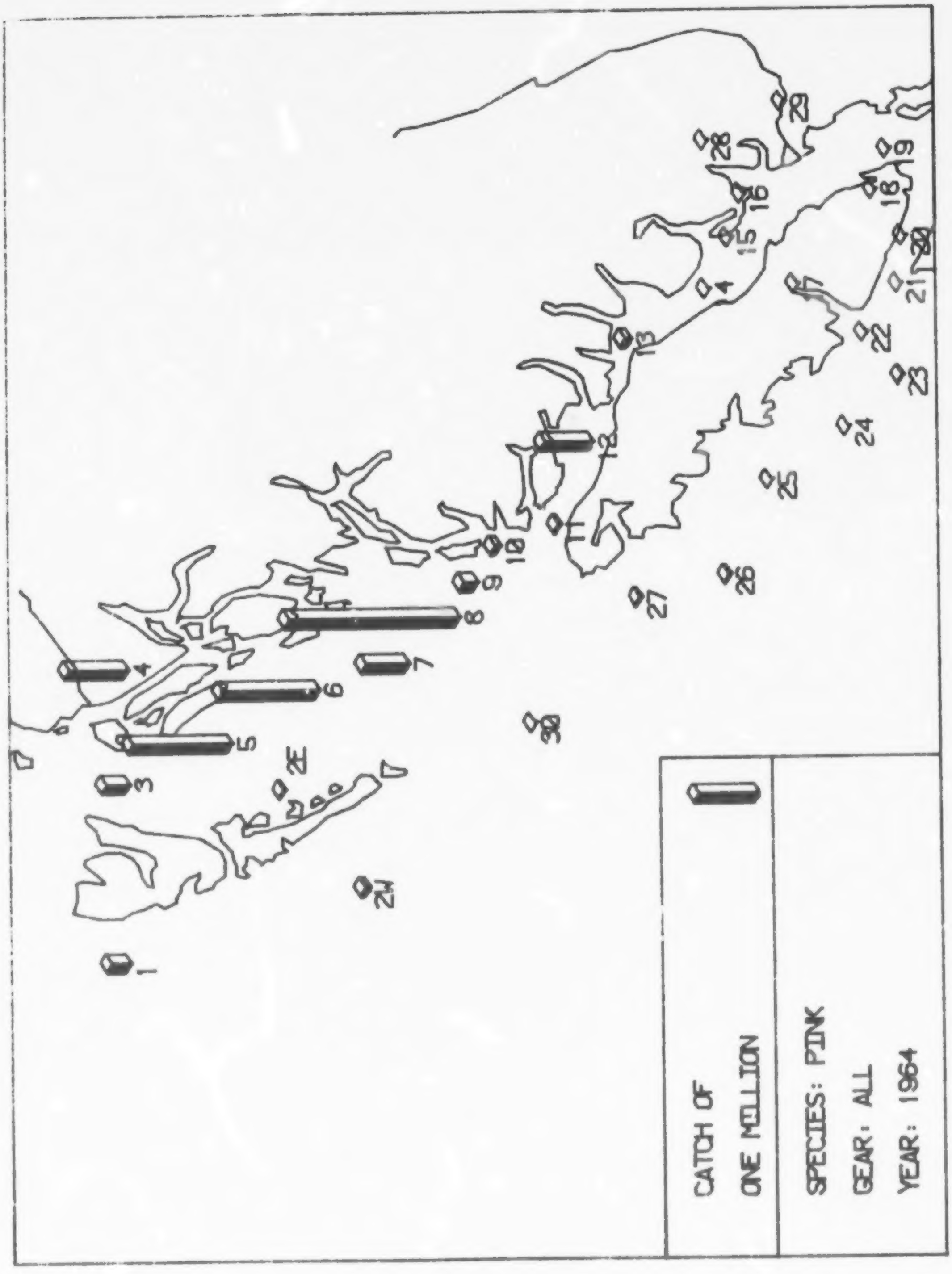
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1964
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B14. Catch of pink salmon by statistical area in 1964.

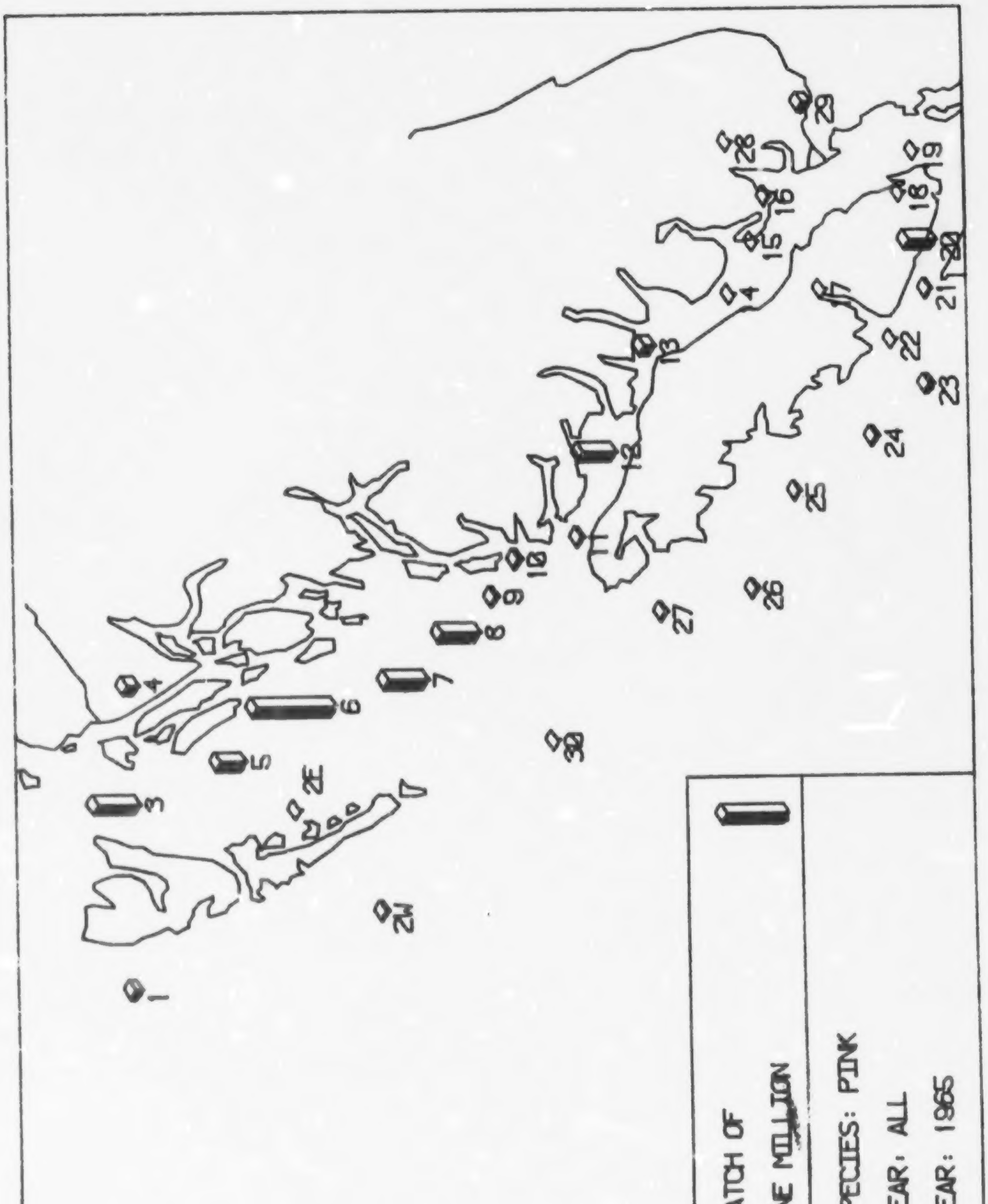
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1965
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B15. Catch of pink salmon by statistical area in 1965.

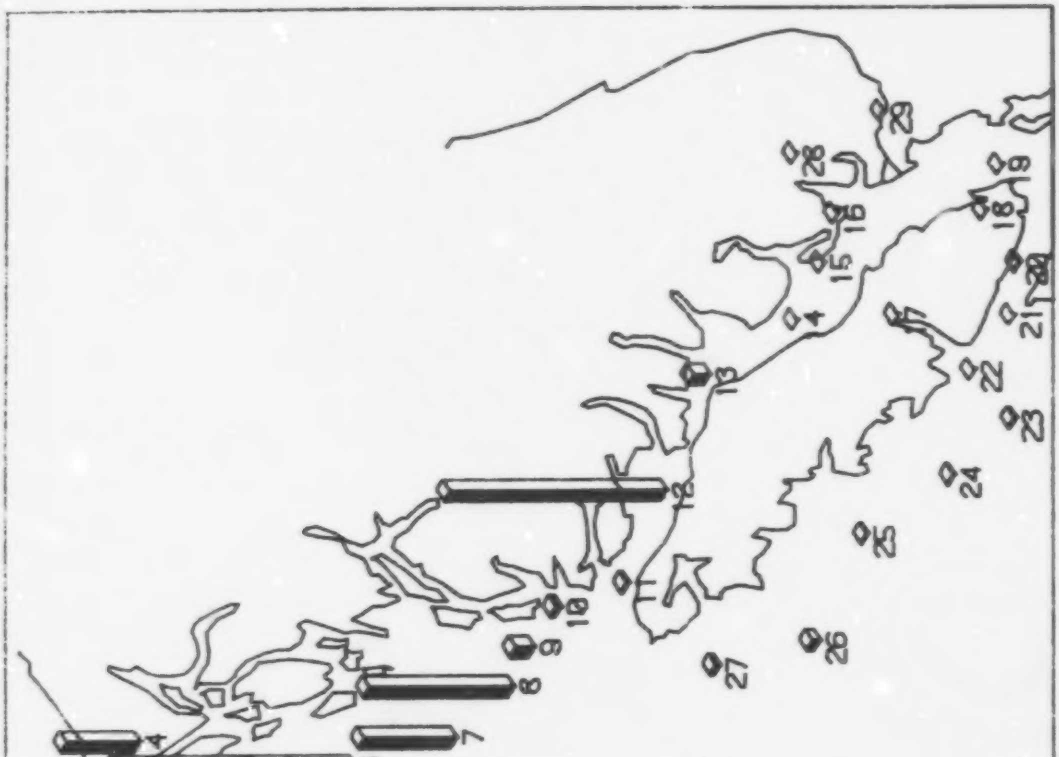
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1966
1
2
3
4
5
6
7
8
9
10
12
13
14
15
16
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B16. Catch of pink salmon by statistical area in 1966.

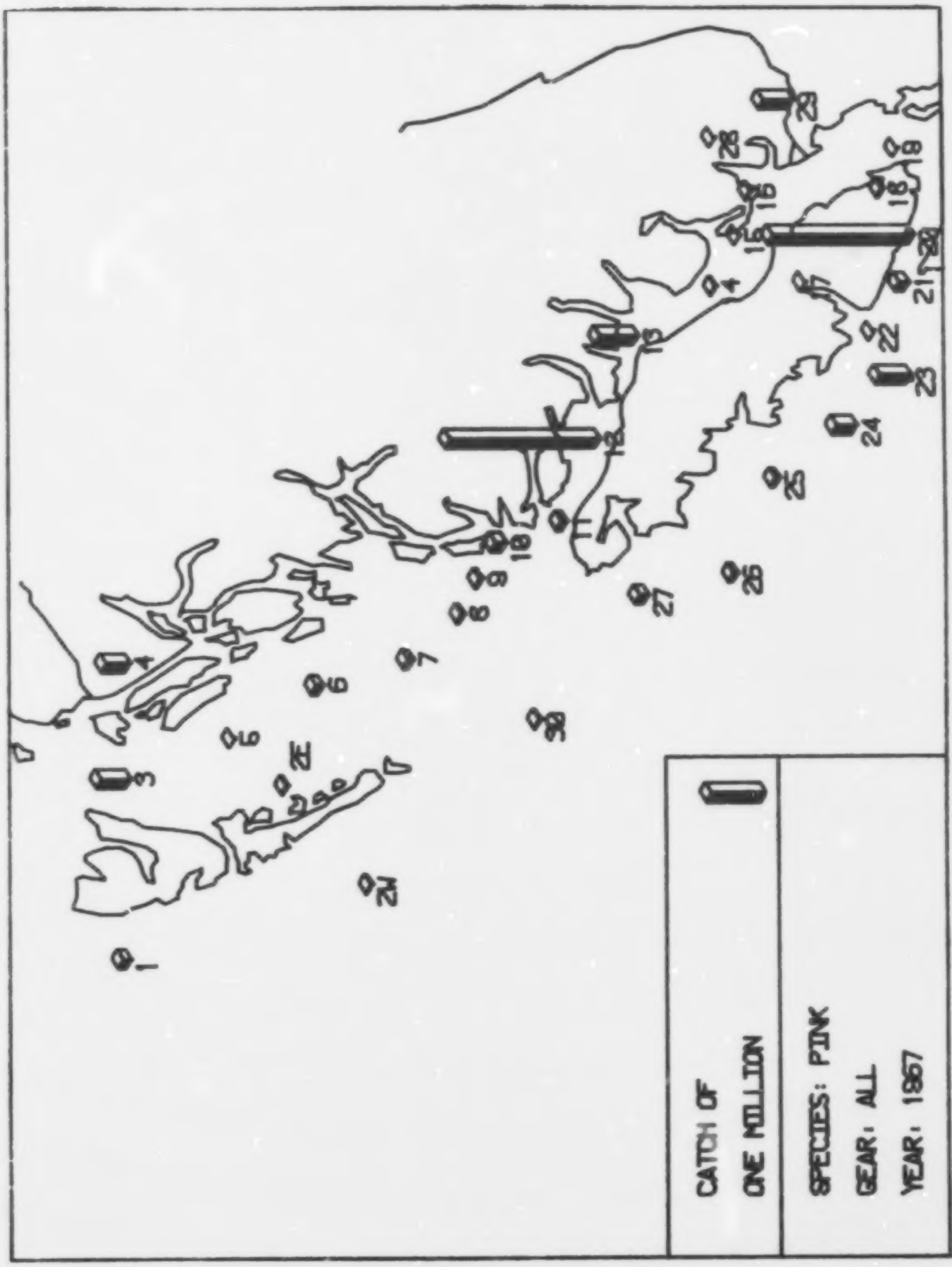
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1967

Fig. B17. Catch of pink salmon by statistical area in 1967.

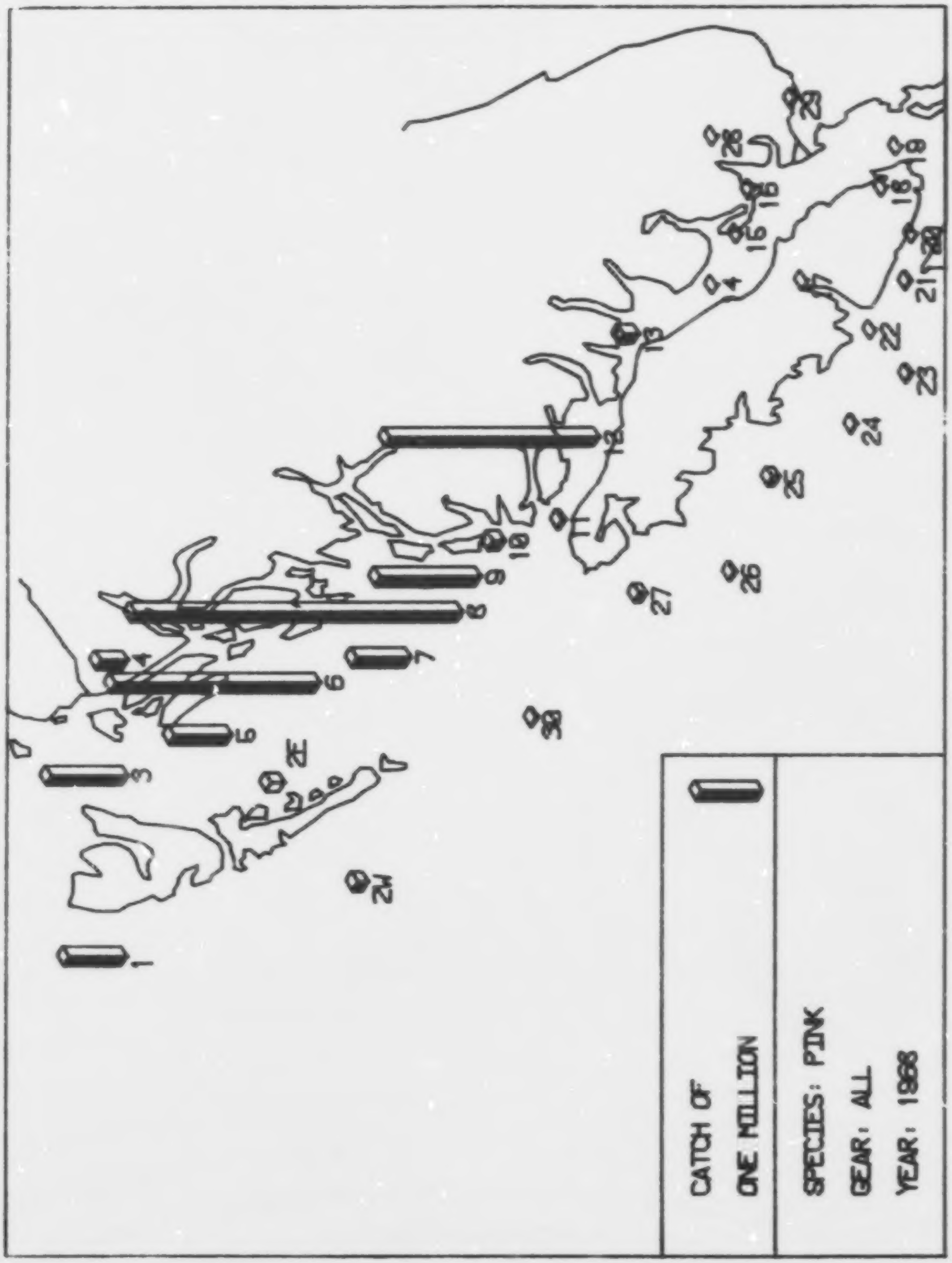
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1968

Fig. B18. Catch of pink salmon by statistical area in 1968.

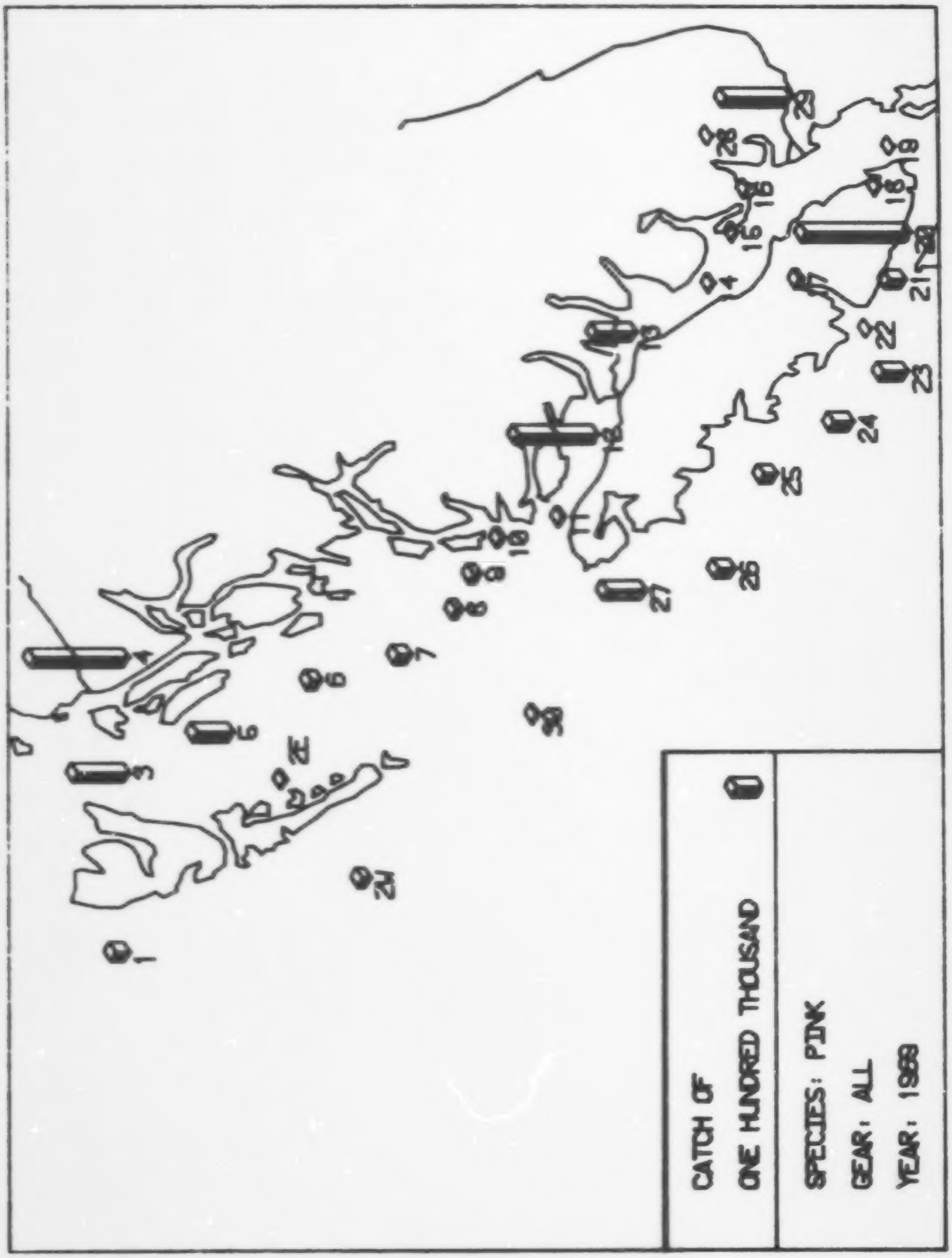
CATCH OF
ONE HUNDRED THOUSAND
SPECIES: PINK
GEAR: ALL
YEAR: 1969
16
21
22
23
24
25
26
27

Fig. B19. Catch of pink salmon by statistical area in 1969.

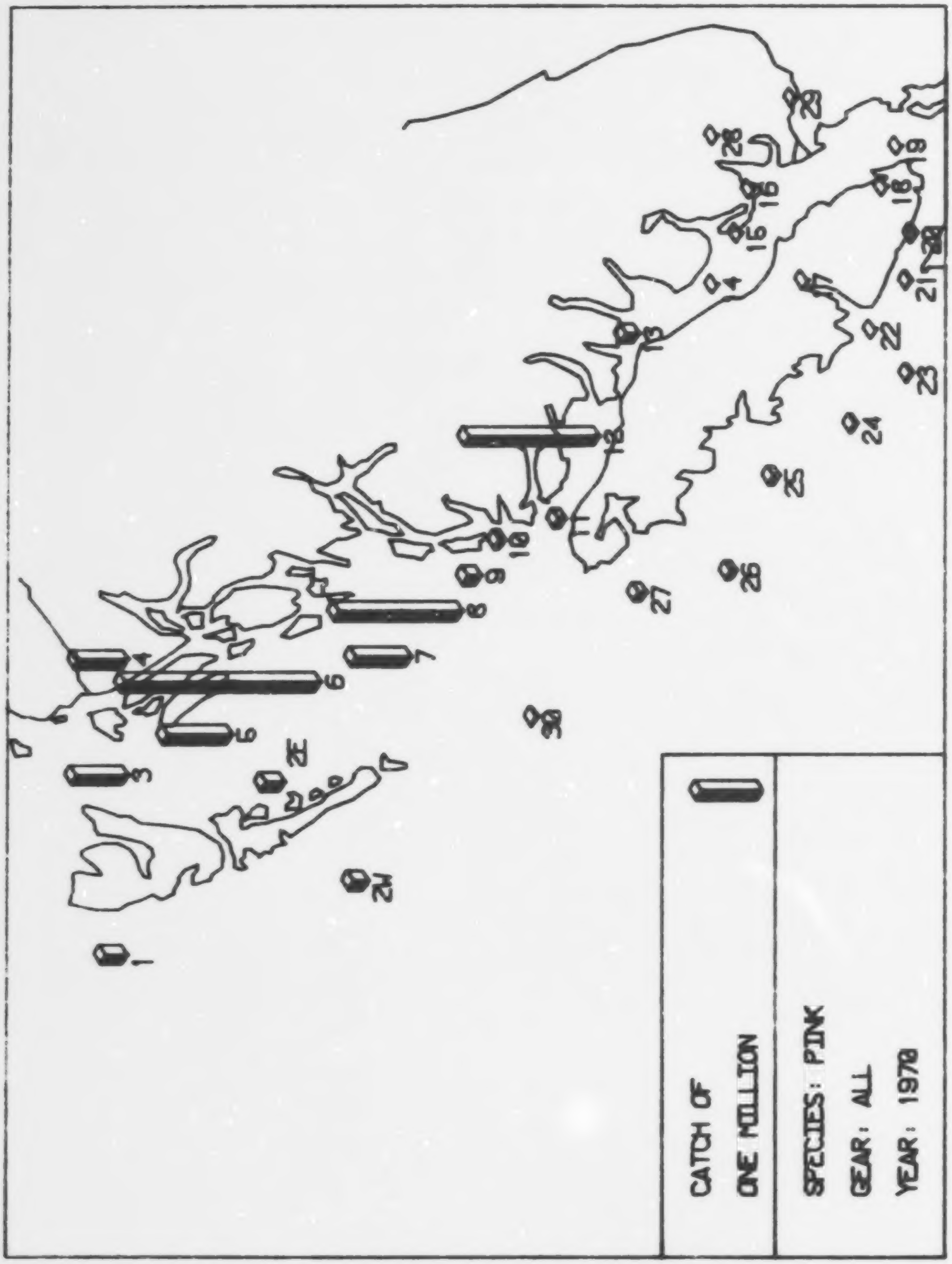
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1970

Fig. B20. Catch of pink salmon by statistical area in 1970.

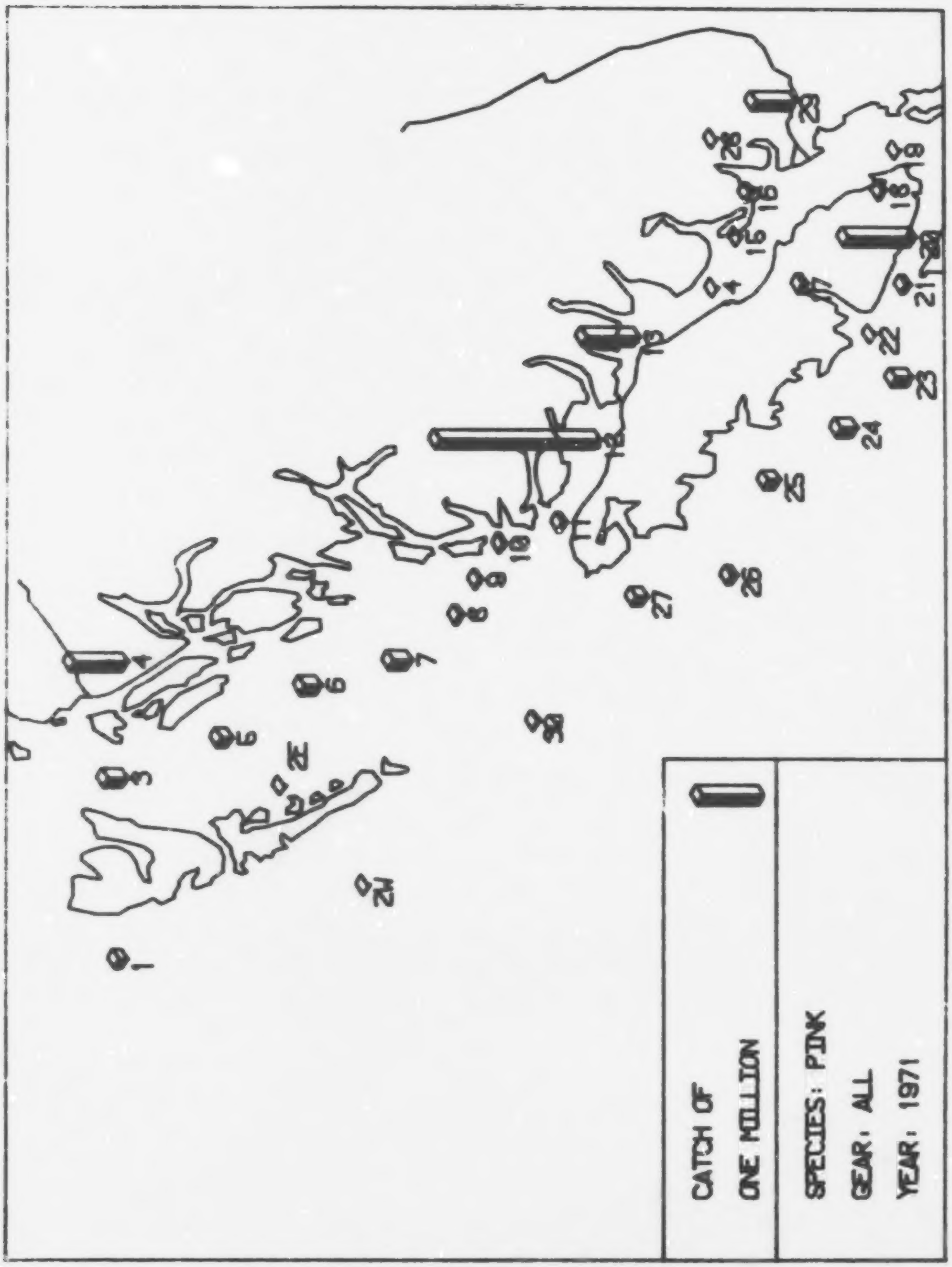
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1971

Fig. B21. Catch of pink salmon by statistical area in 1971.

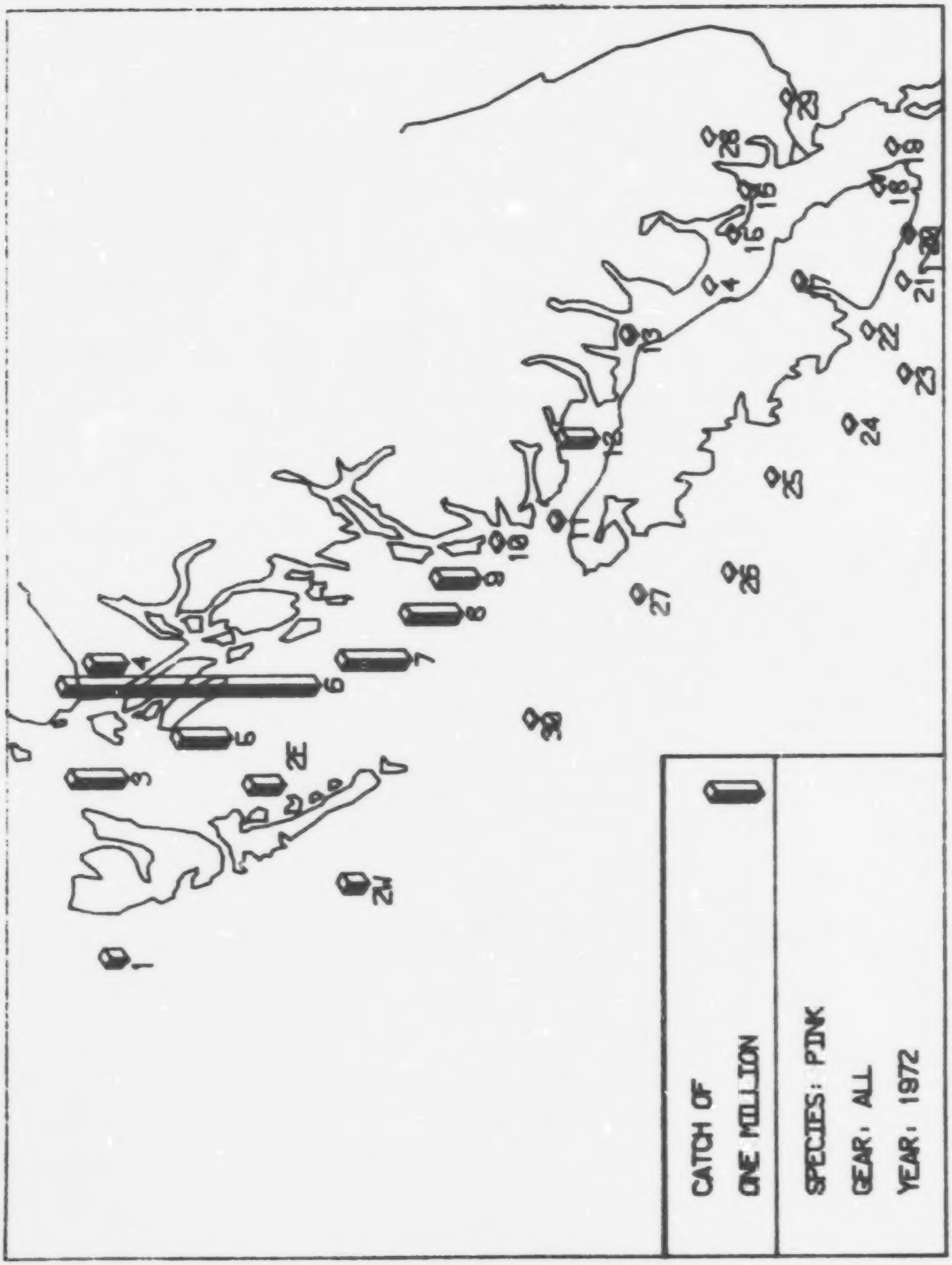
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1972
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
18
19
21
22
23
24
25
26
27
28
29
30

Fig. B22. Catch of pink salmon by statistical area in 1972.

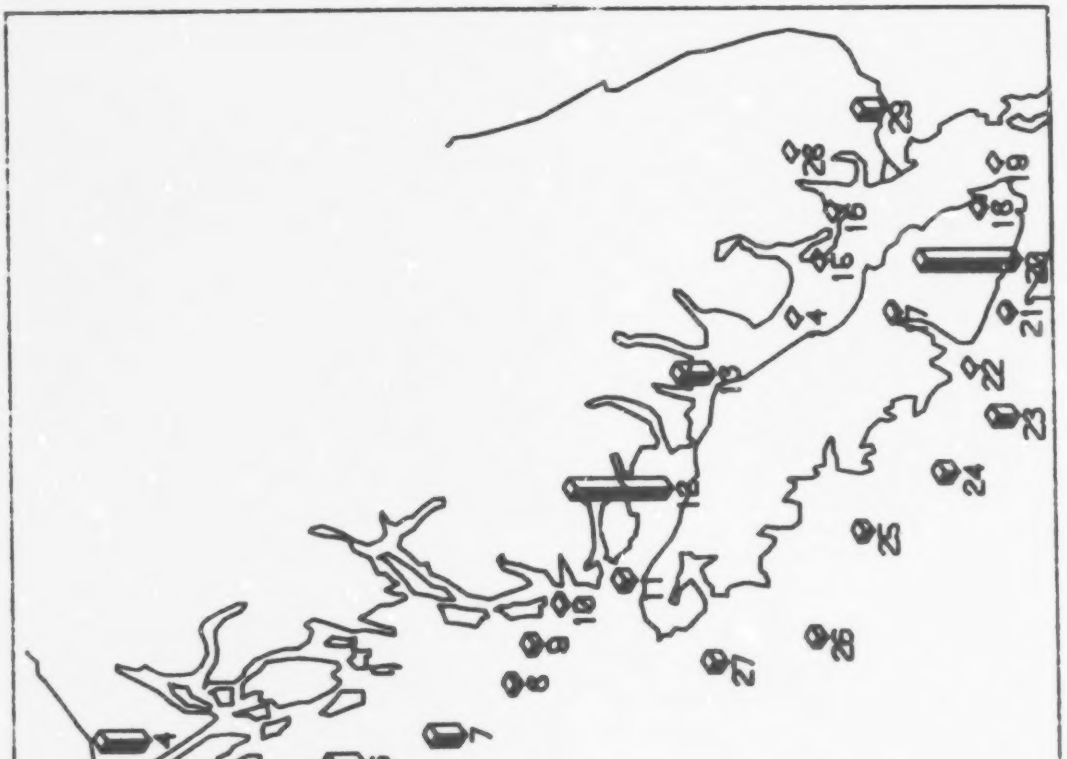
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1973

Fig. B23. Catch of pink salmon by statistical area in 1973.

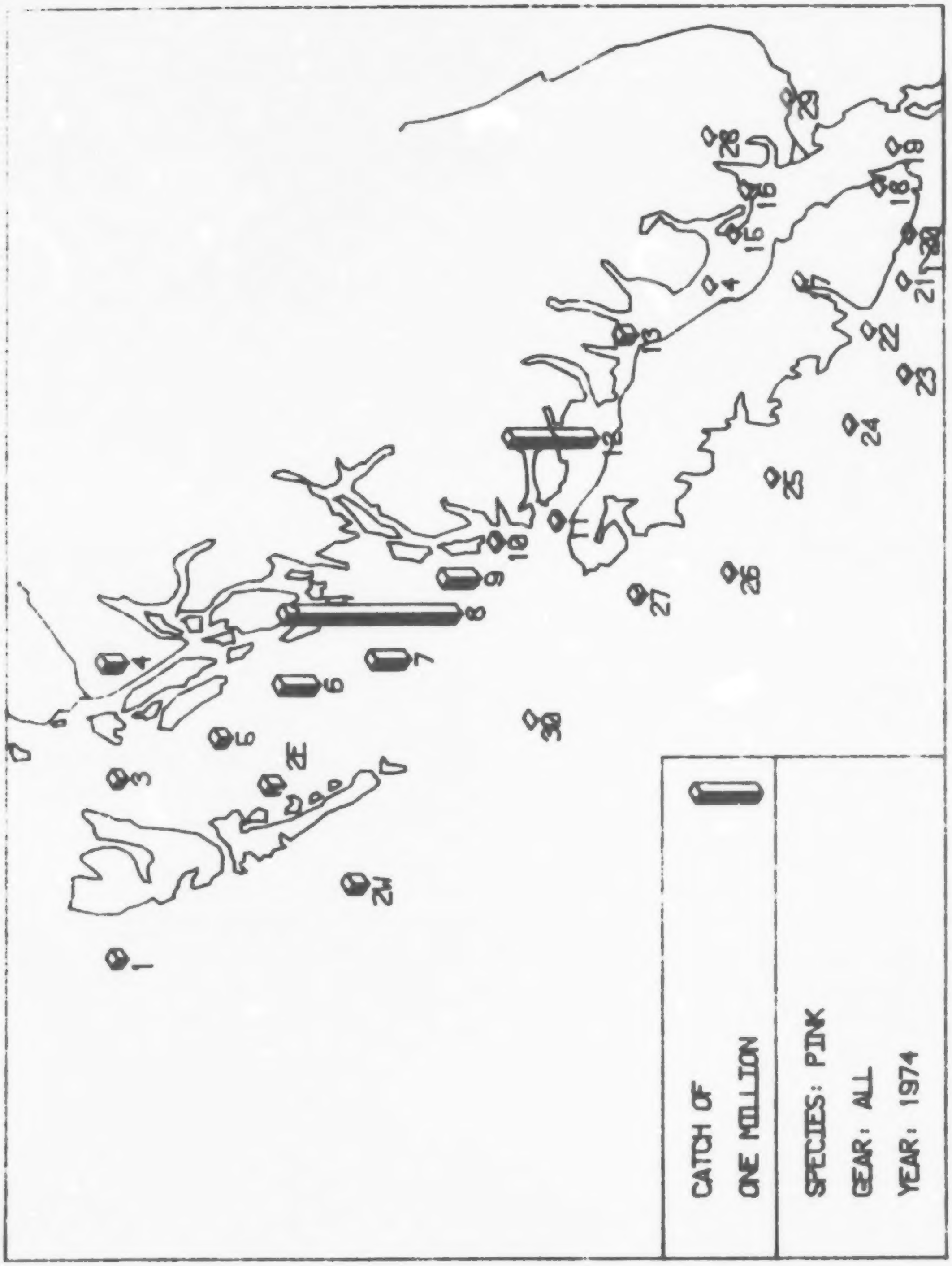
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1974
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B24. Catch of pink salmon by statistical area in 1974.

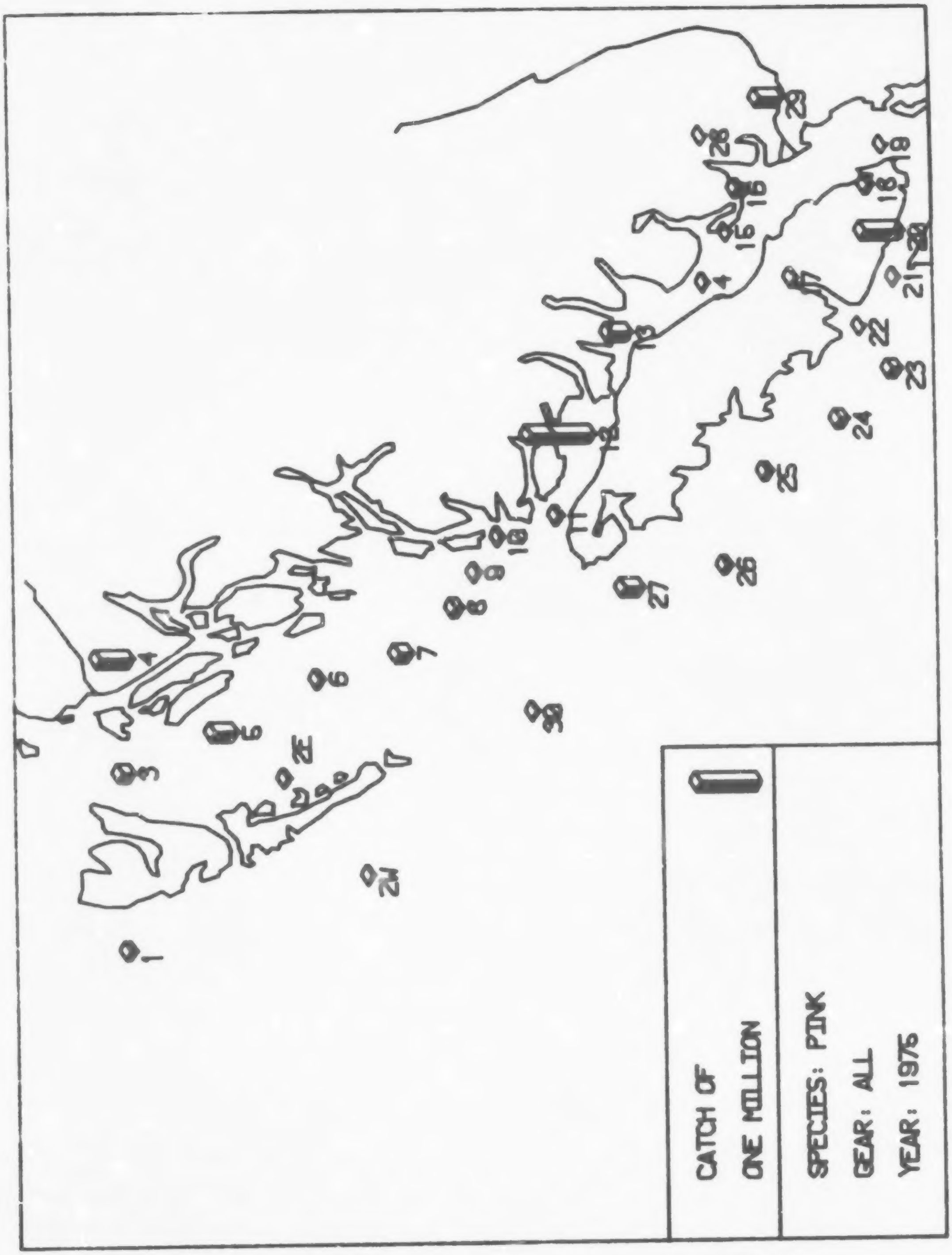
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1975

Fig. B25. Catch of pink salmon by statistical area in 1975.

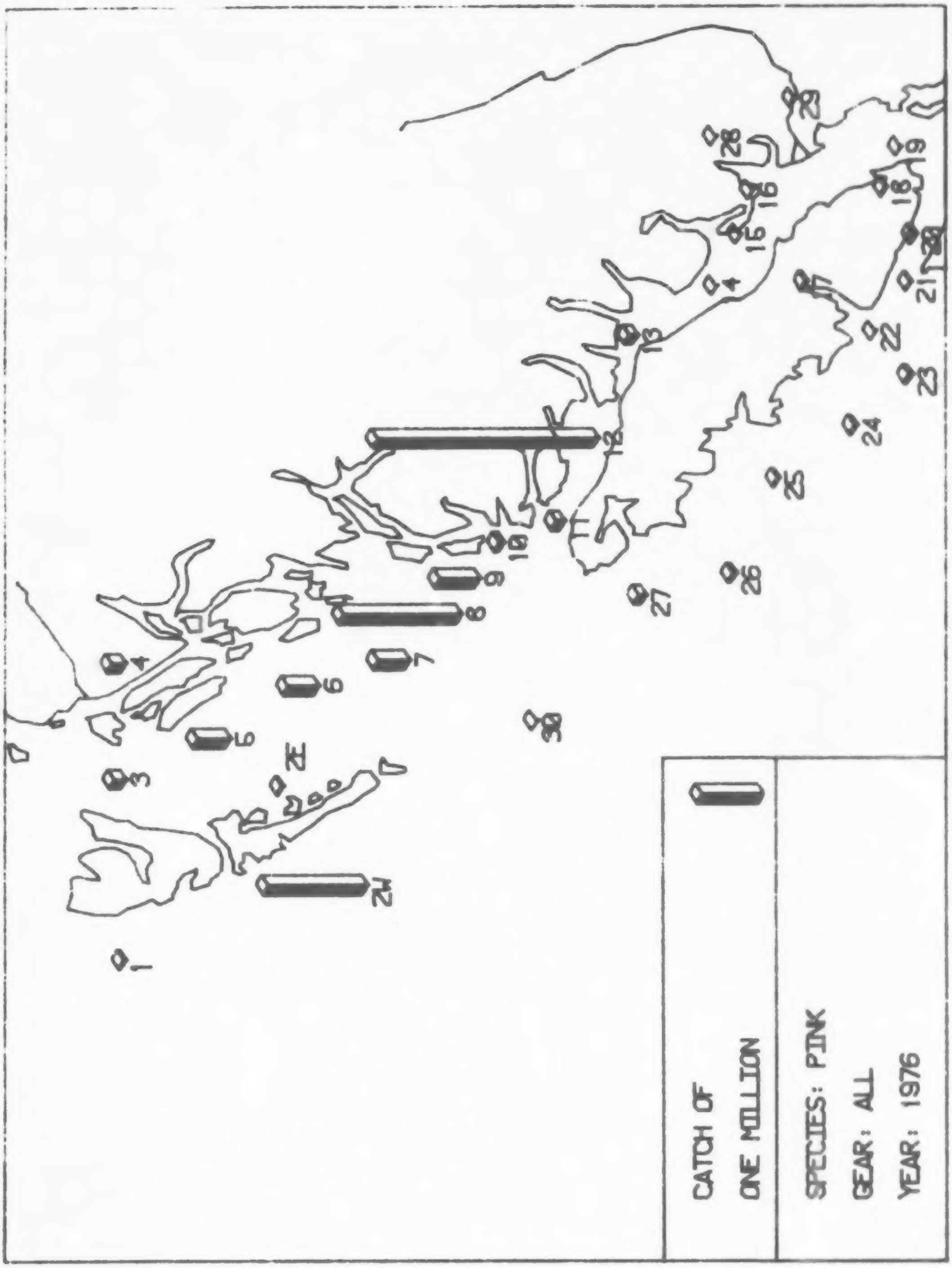
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1976
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B26. Catch of pink salmon by statistical area in 1976.

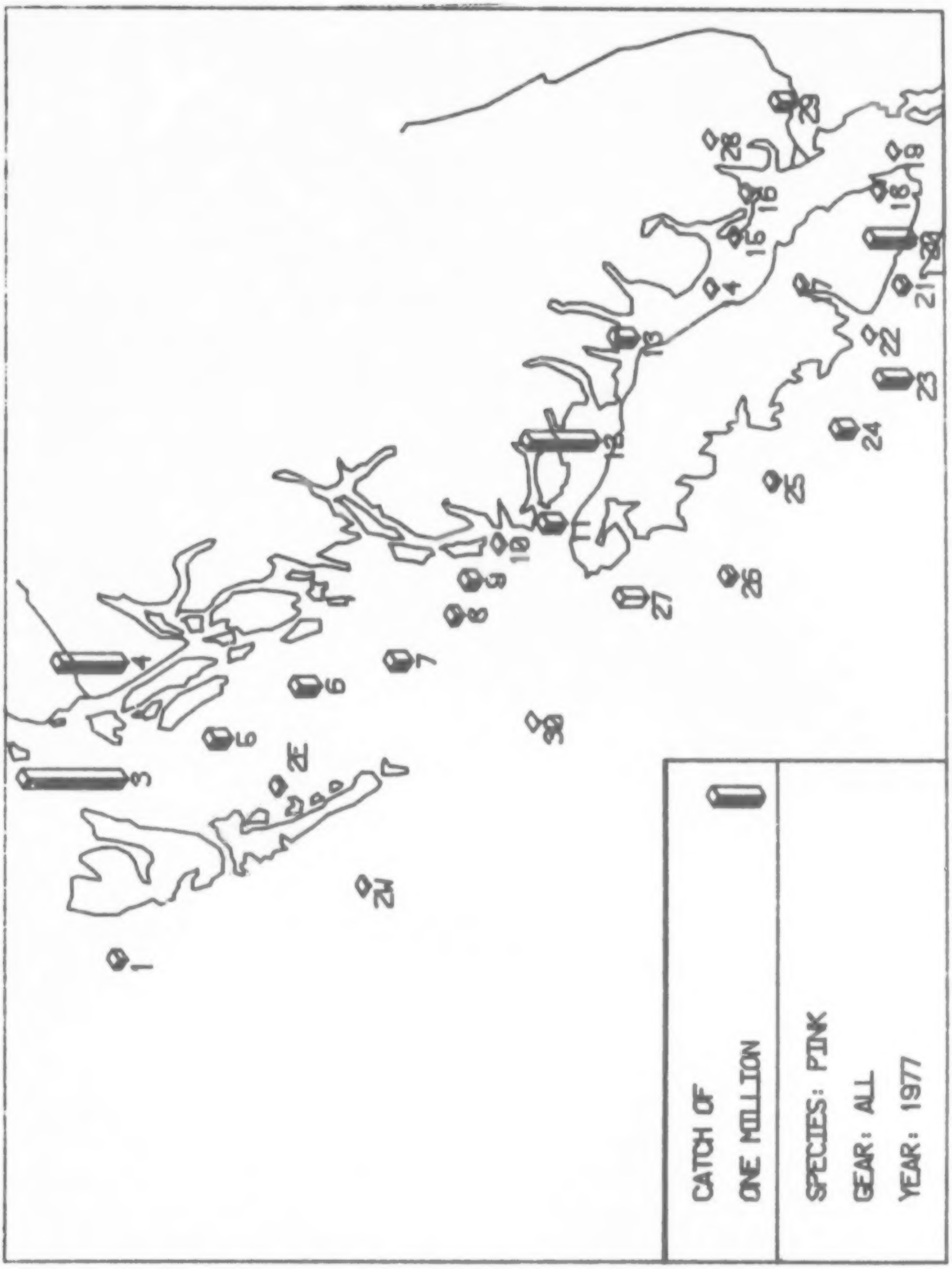
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1977
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Fig. B27. Catch of pink salmon by statistical area in 1977.

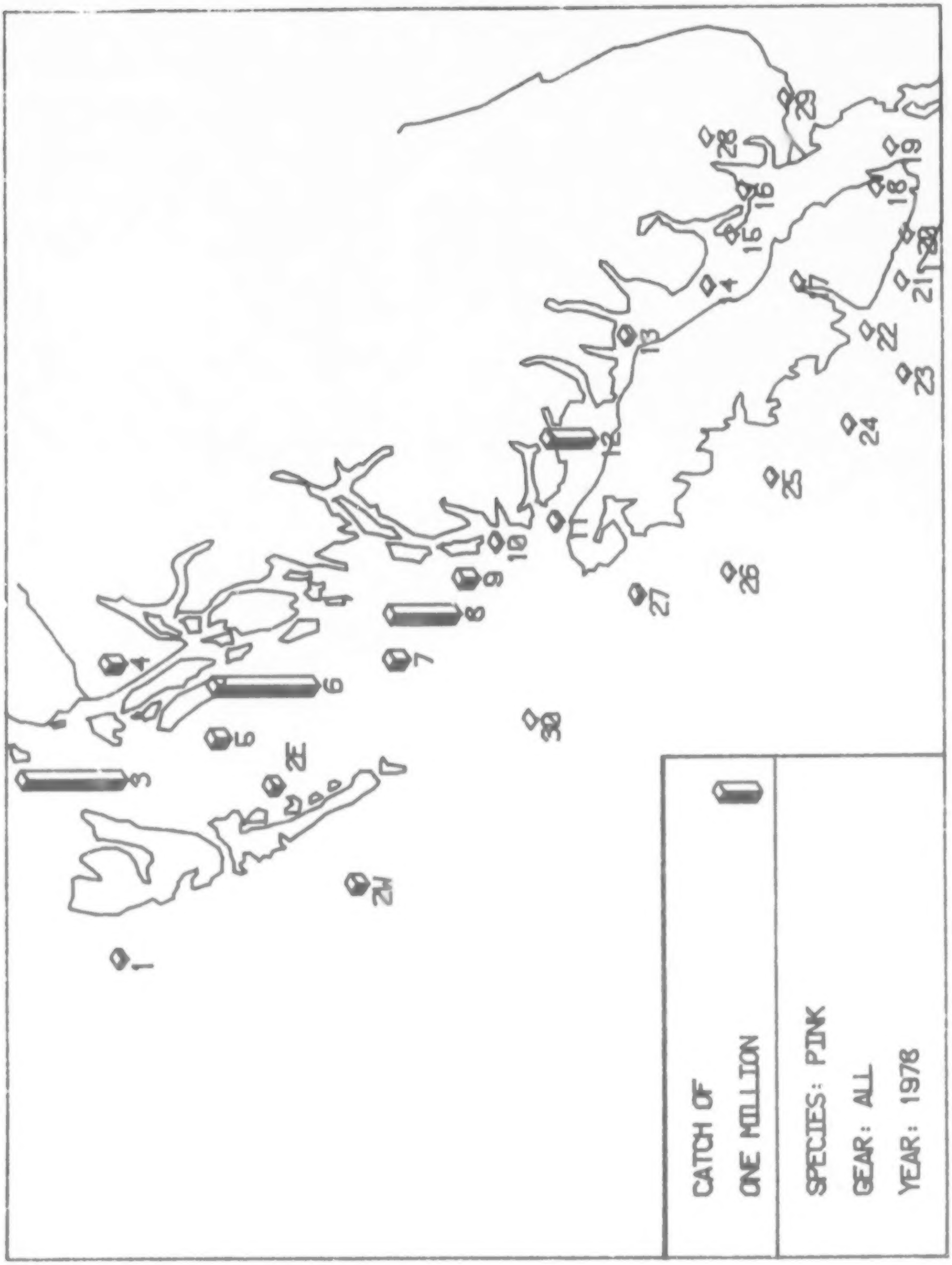
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1978
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B28. Catch of pink salmon by statistical area in 1978.

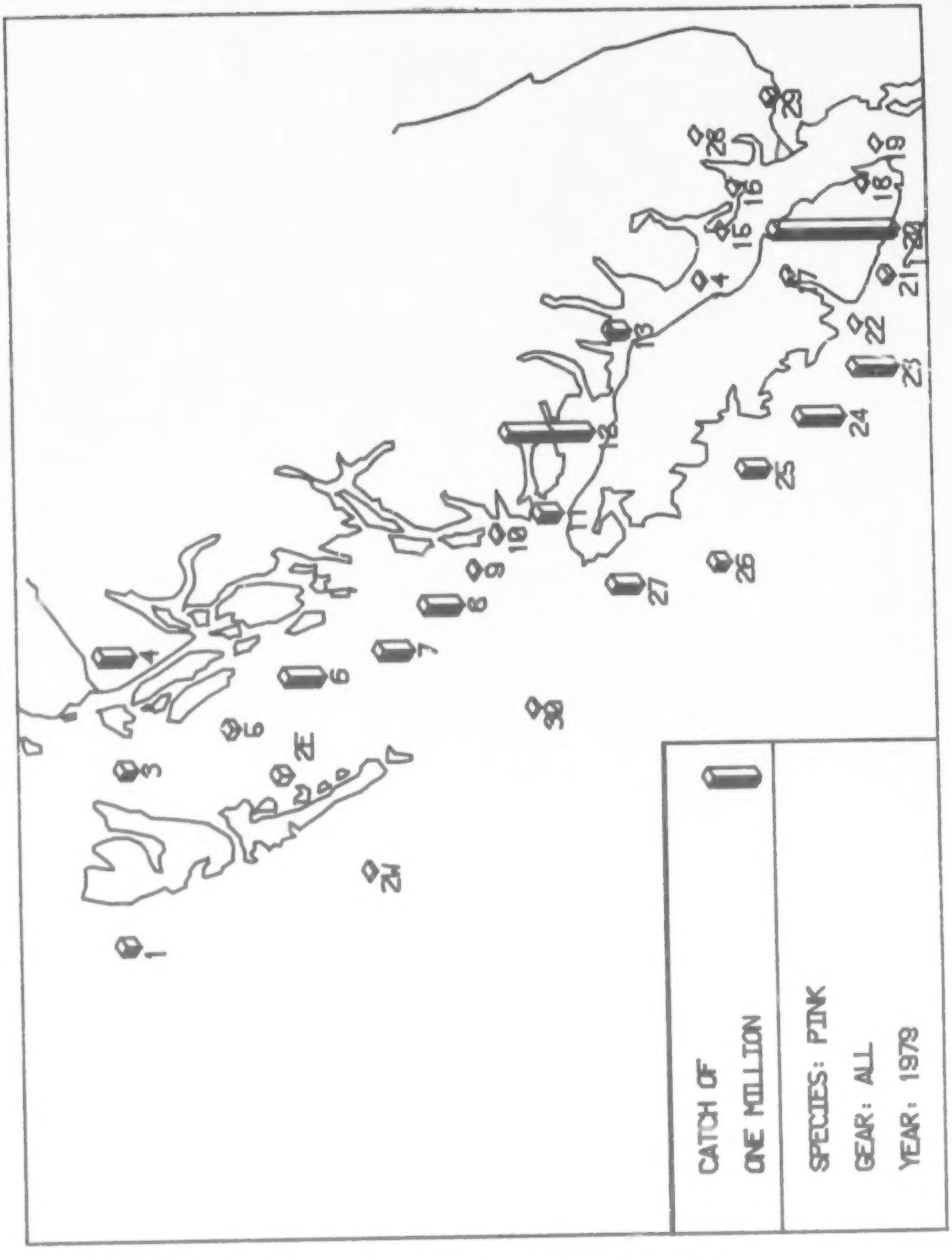
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1979

Fig. B29. Catch of pink salmon by statistical area in 1979.

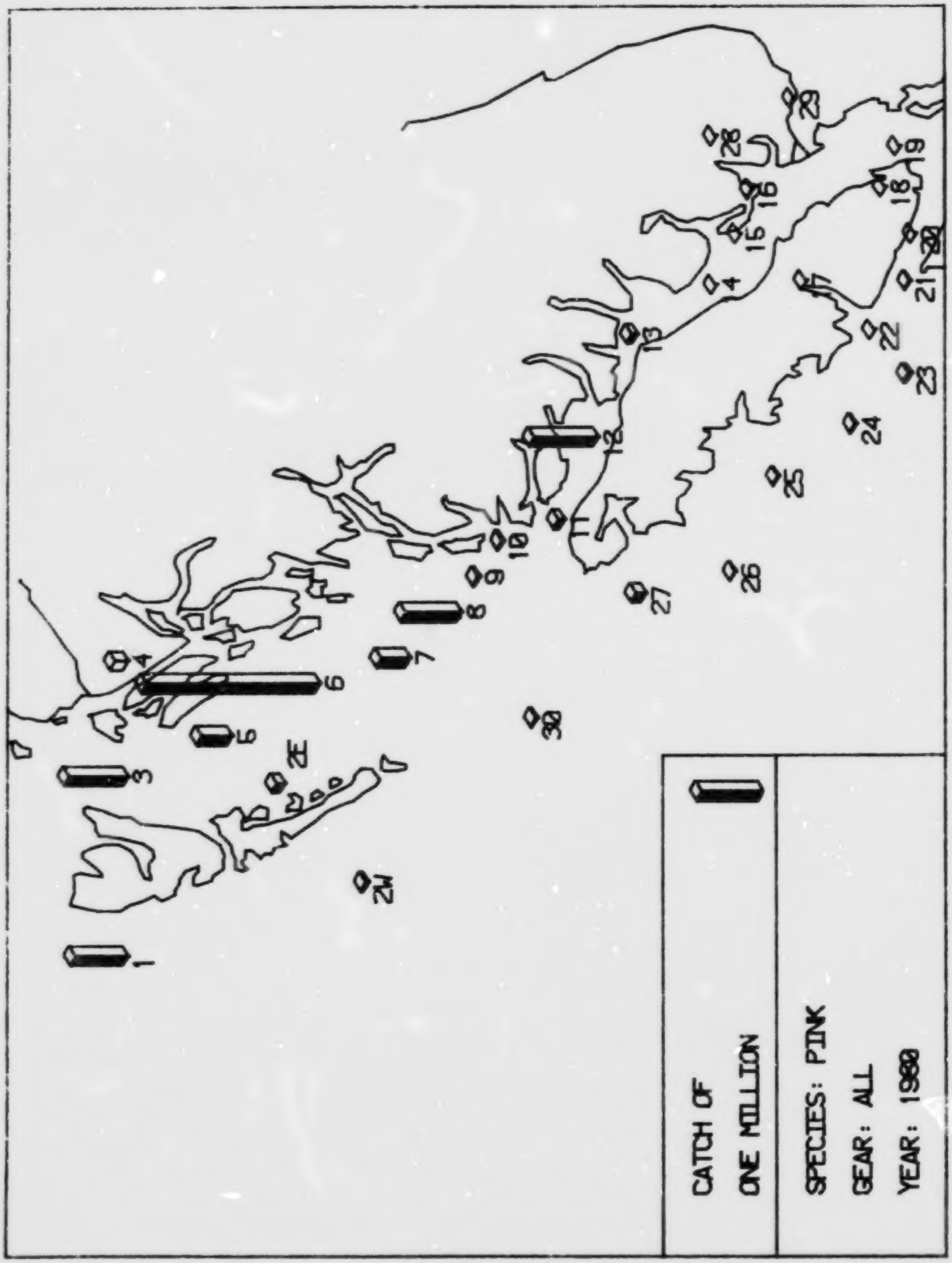
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1980
1
2W
3
3E
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. B30. Catch of pink salmon by statistical area in 1980.

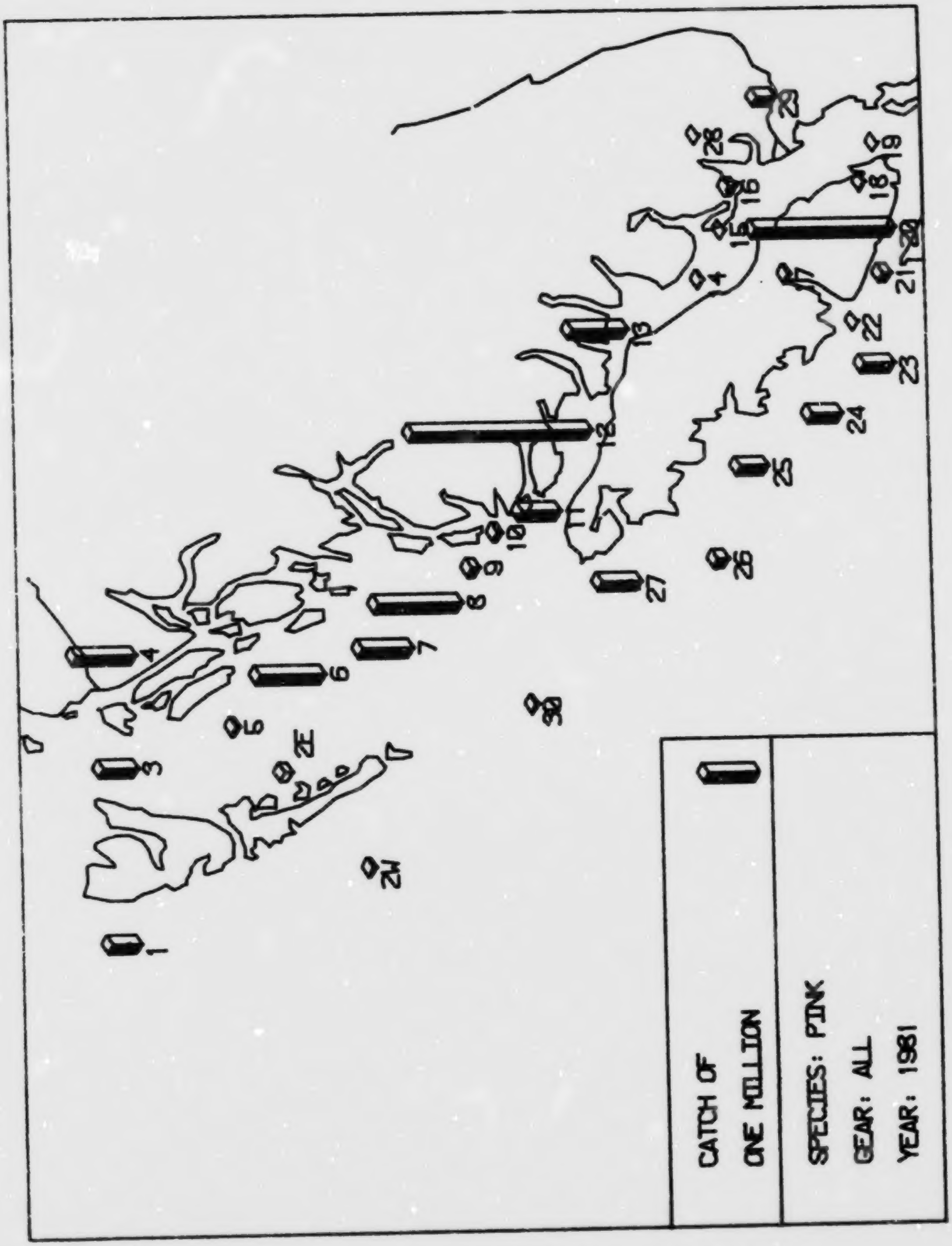
CATCH OF
ONE MILLION
SPECIES: PINK
GEAR: ALL
YEAR: 1981
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
18
19
20
21
22
23
24
25
26
27
28
30

Fig. B31. Catch of pink salmon by statistical area in 1981.

APPENDIX C

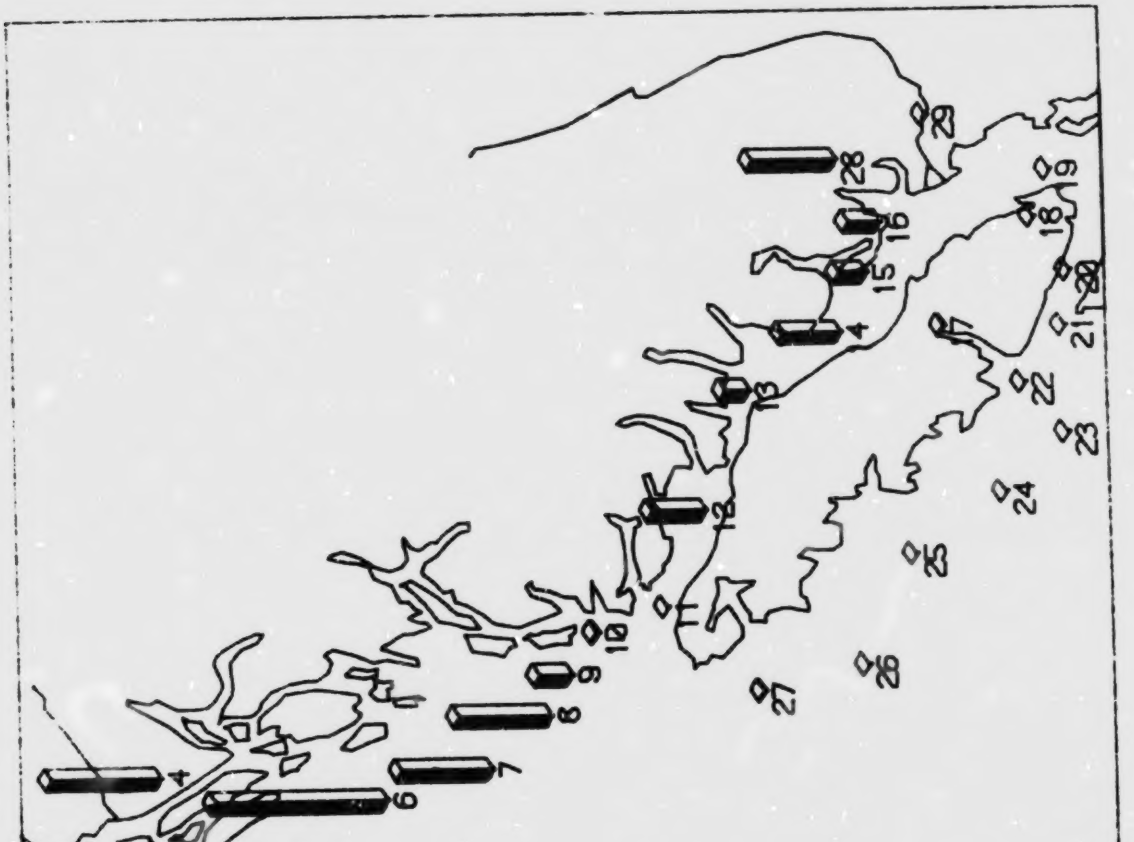
ESCAPEMENT IN
ONE HUNDRED THOUSAND
SPECIES: PINK
YEAR: 1951
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C1. Escapement of pink salmon by Statistical Area in 1951.

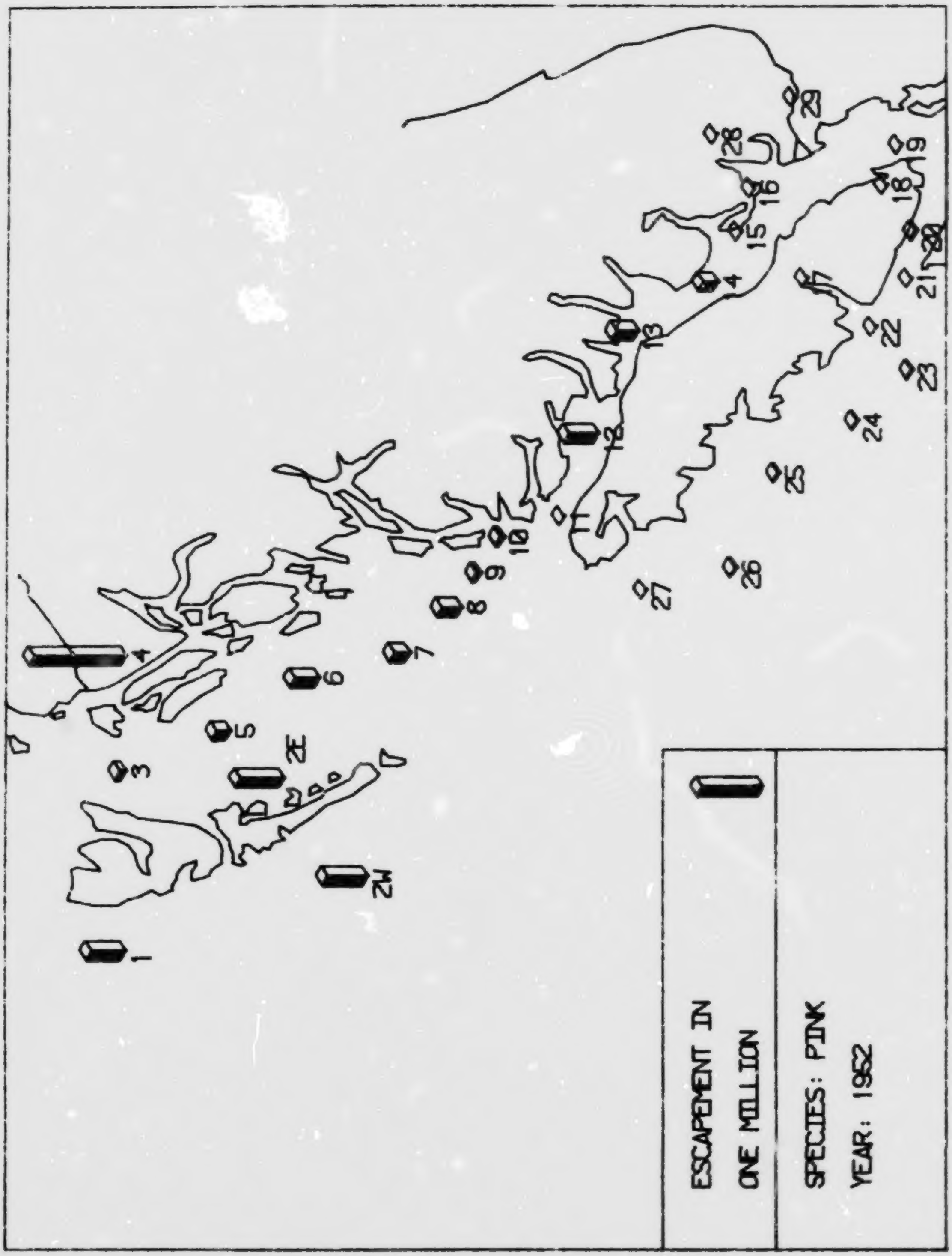
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1952
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C2. Escapement of pink salmon by Statistical Area in 1952.

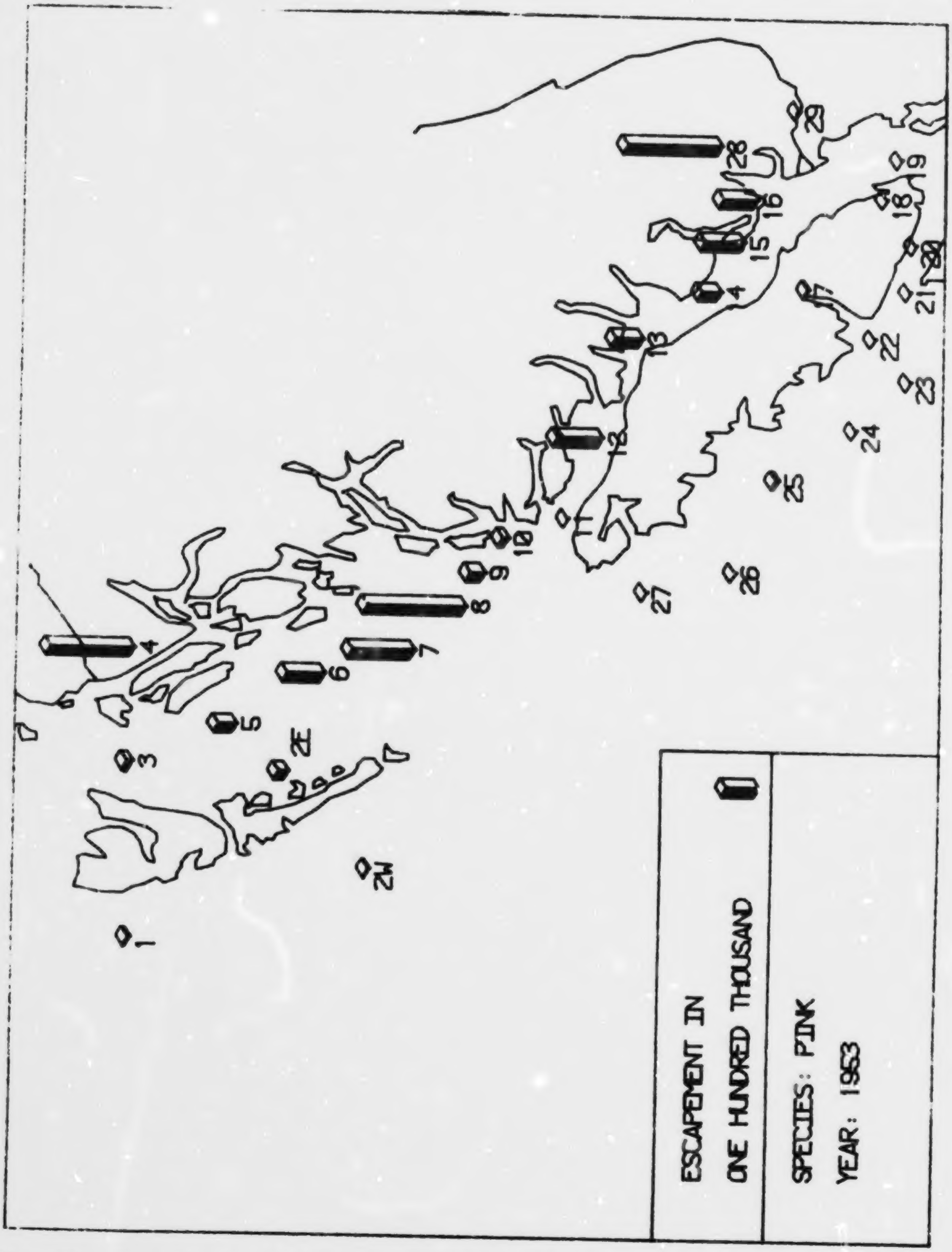
ESCAPEMENT IN
ONE HUNDRED THOUSAND
SPECIES: PINK
YEAR: 1953
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C3. Escapement of pink salmon by Statistical Area in 1953.

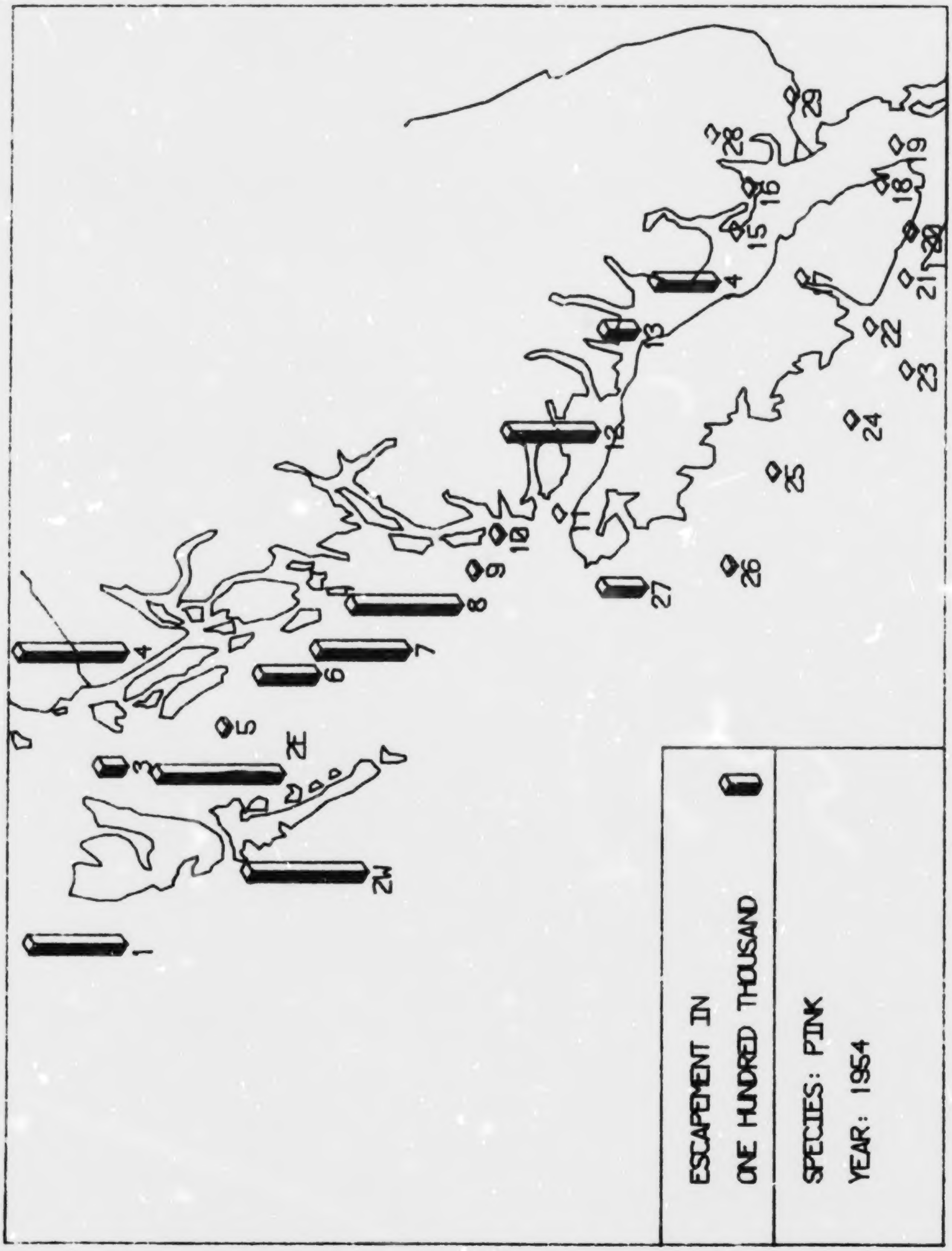
1
2W
3
3E
4
5
6
7
8
9
10
12
13
4
15
16
28
29
17
18
19
20
21
22
23
24
25
26
27
ESCAPEMENT IN
ONE HUNDRED THOUSAND
SPECIES: PINK
YEAR: 1954

Fig. C4. Escapement of pink salmon by Statistical Area in 1954.

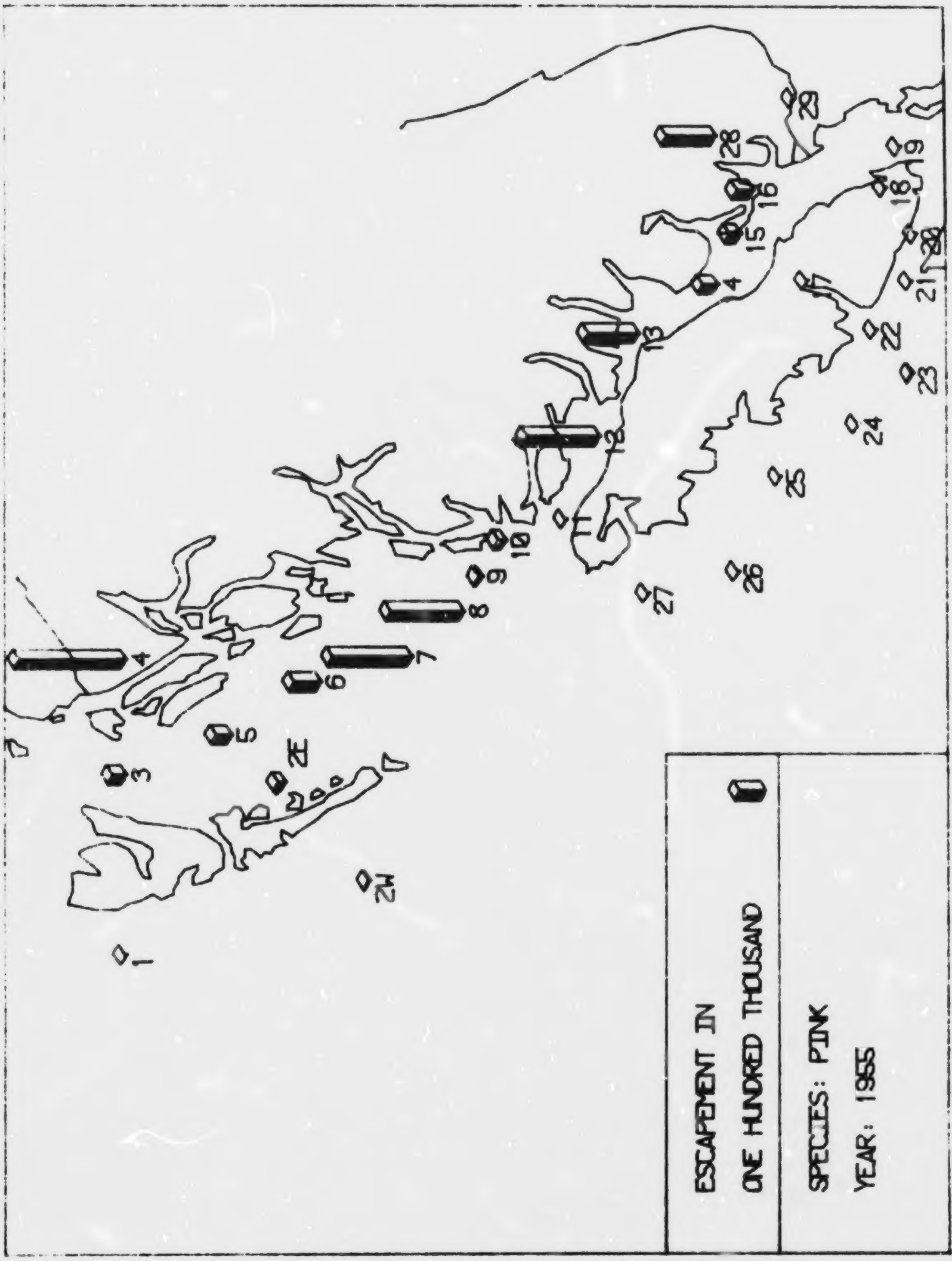
ESCAPEMENT IN
ONE HUNDRED THOUSAND
SPECIES: PINK
YEAR: 1955
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C5. Escapement of pink salmon by Statistical Area in 1955.

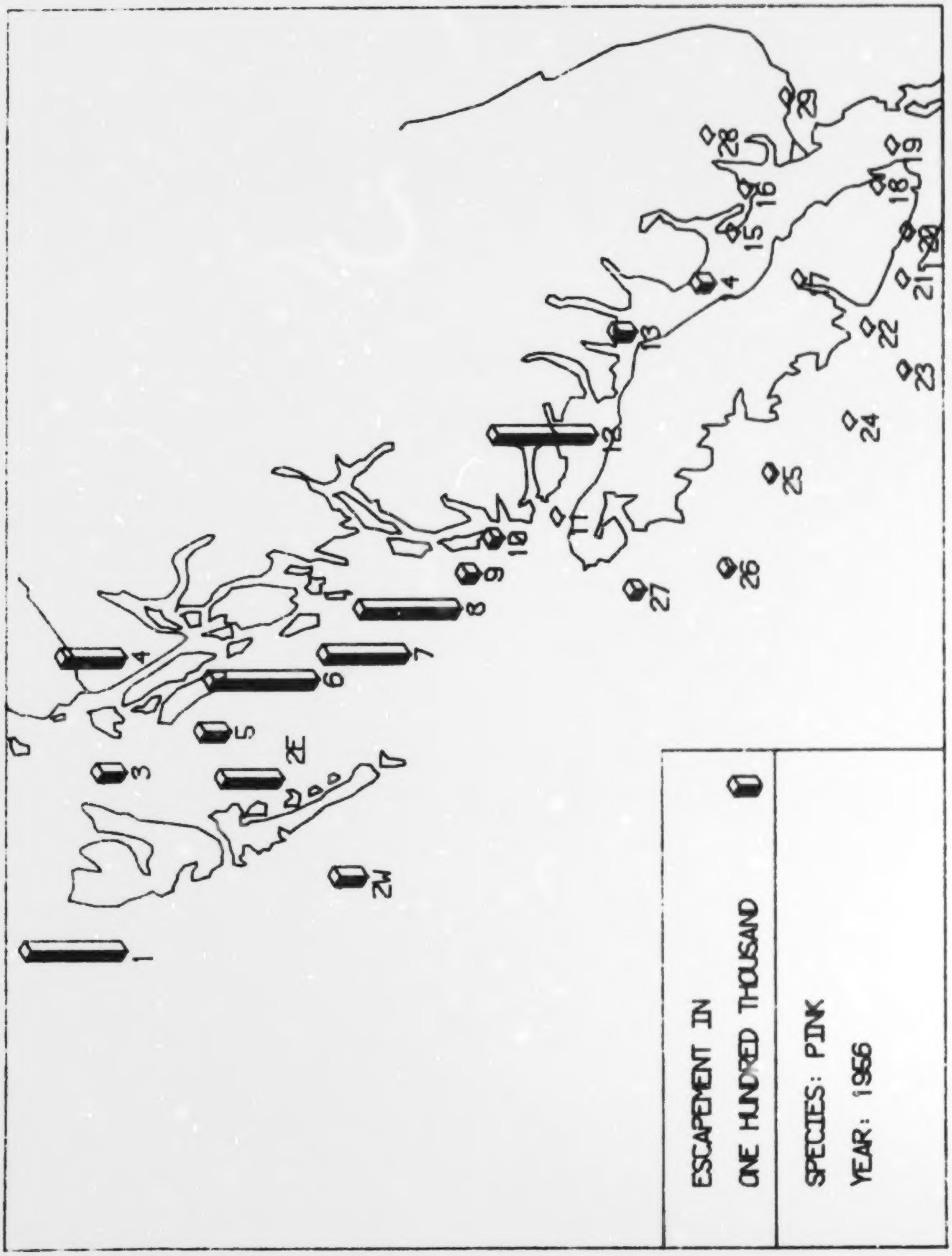
ESCAPEMENT IN
ONE HUNDRED THOUSAND
SPECIES: PINK
YEAR: 1956
1
2W
3
2E
5
4
6
7
8
9
10
12
13
4
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C6. Escapement of pink salmon by Statistical Area in 1956.

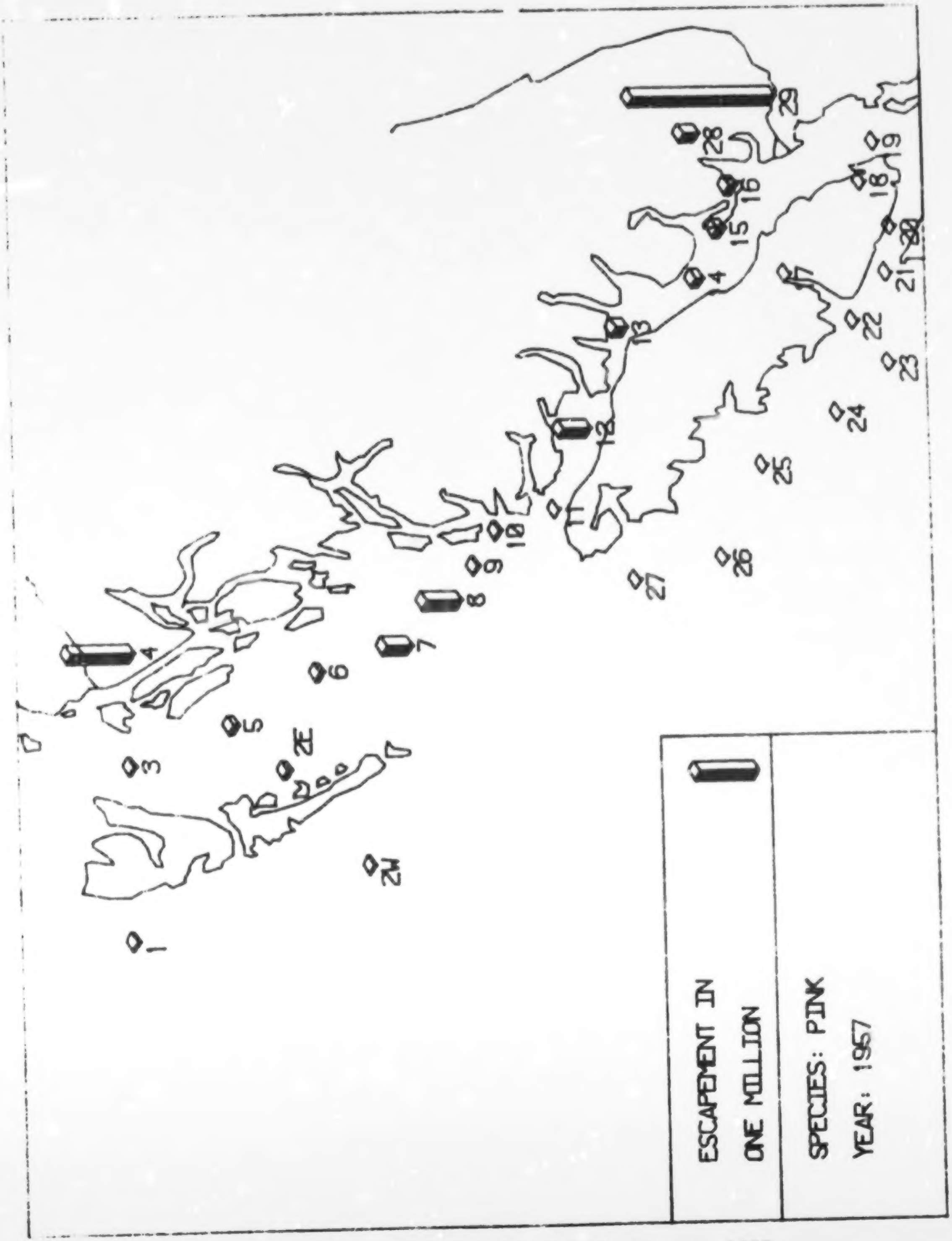
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1957
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C7. Escapement of pink salmon by Statistical Area in 1957.

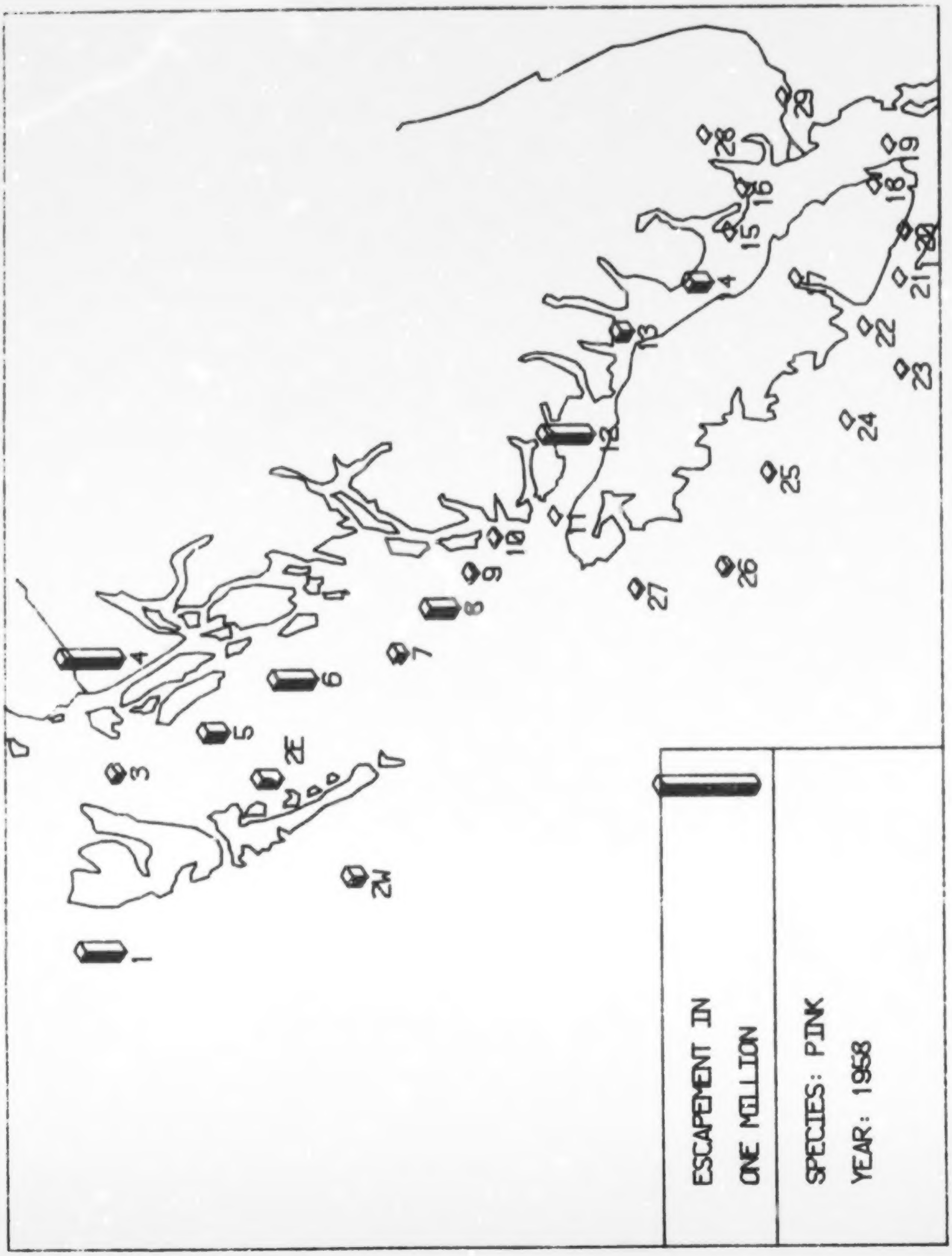
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1958
1
2N
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C8. Escapement of pink salmon by Statistical Area in 1958.

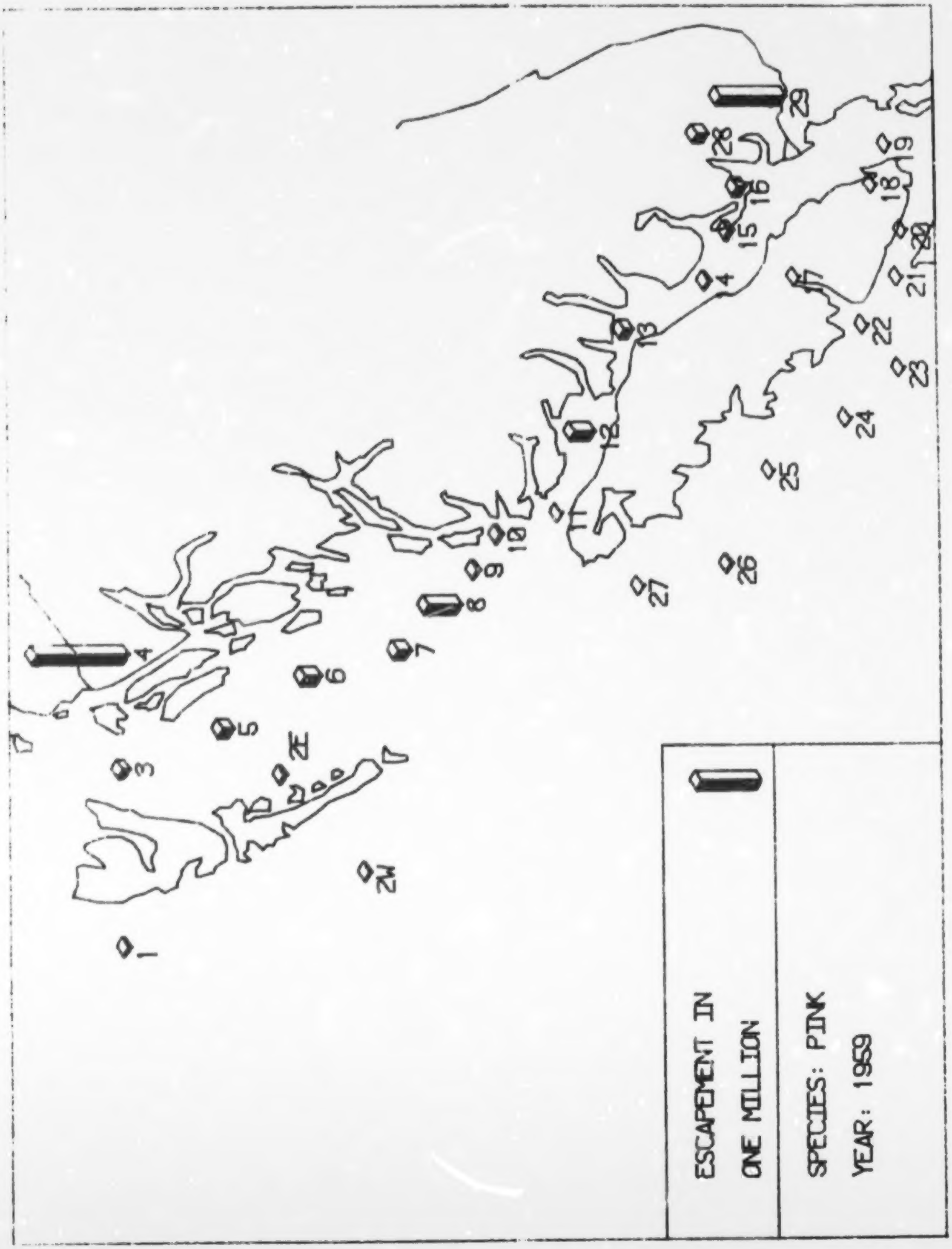
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1959
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C9. Escapement of pink salmon by Statistical Area in 1959.

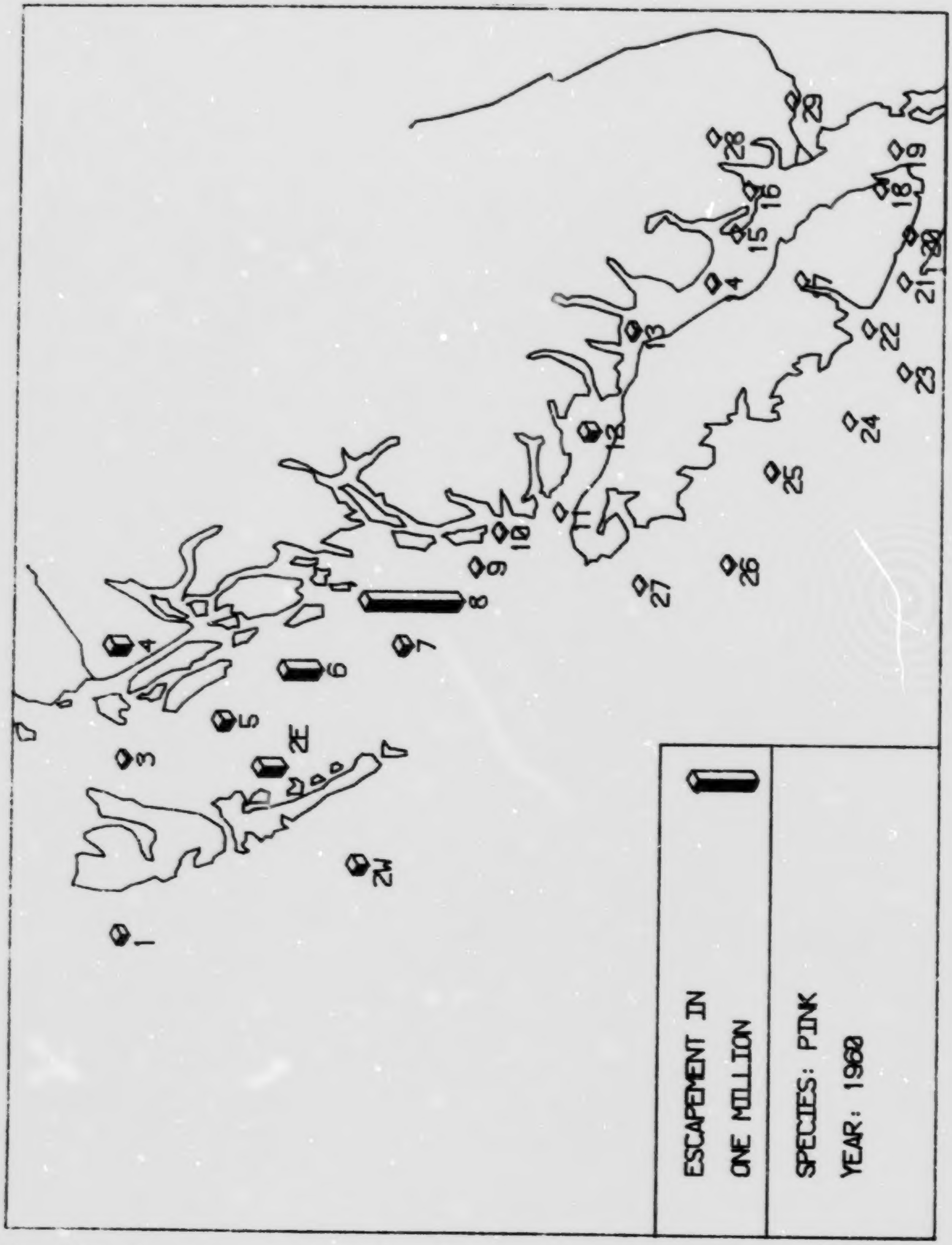
1
2W
3
2E
5
4
6
7
8
9
10
12
13
14
15
16
28
29
17
18
19
20
21
22
23
24
25
26
27
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1960

Fig. C10. Escapement of pink salmon by Statistical Area in 1960.

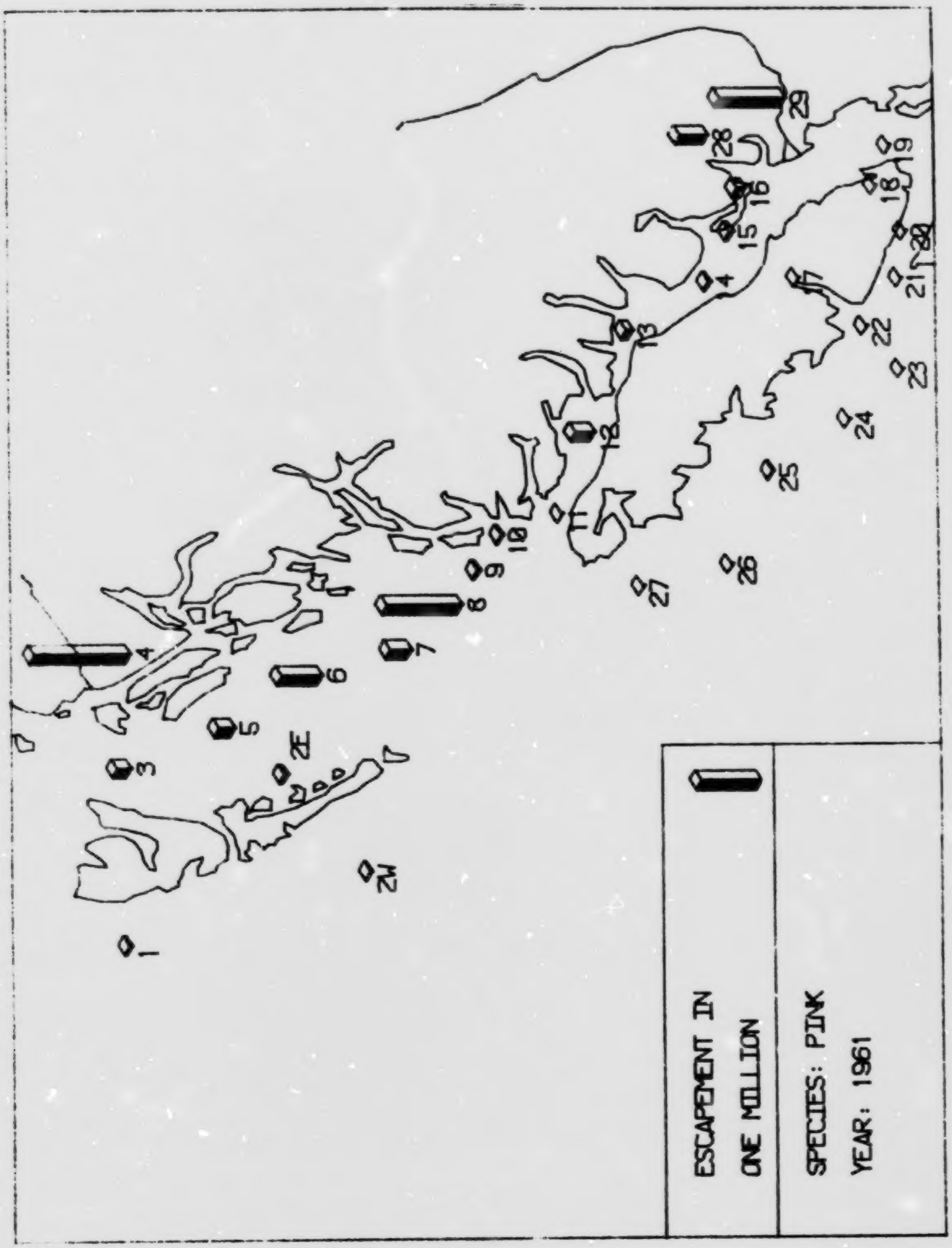
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1961
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C11. Escapement of pink salmon by Statistical Area in 1961.

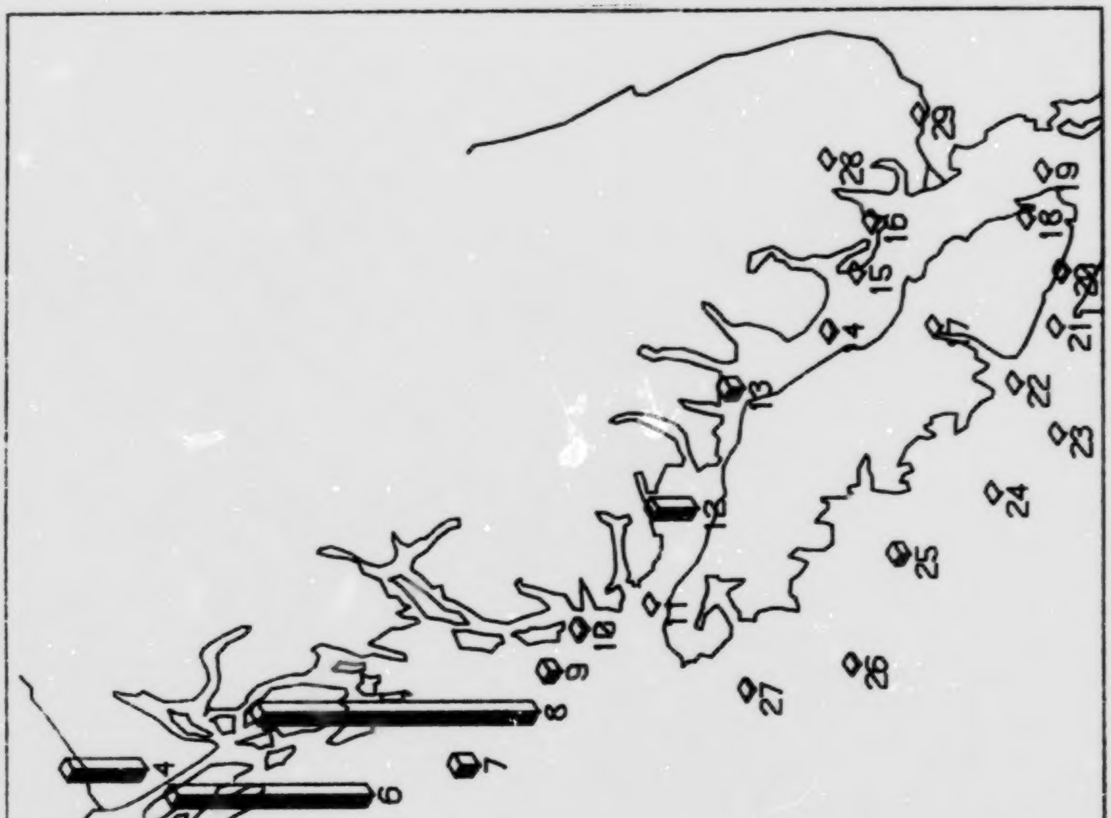
1
2W
3
2E
5
4
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1962

Fig. C12. Escapement of pink salmon by Statistical Area in 1962.

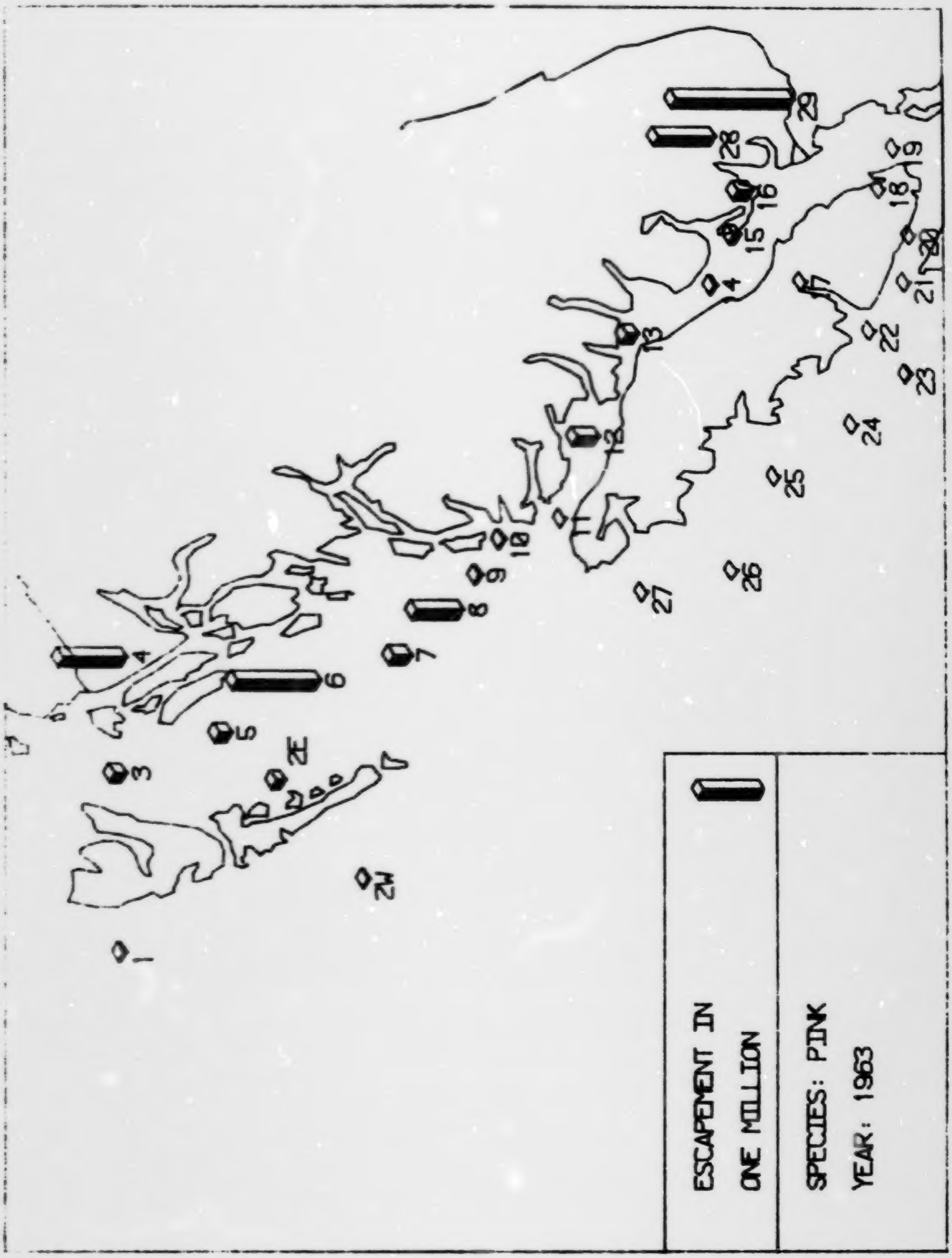
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1963
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C13. Escapement of pink salmon by Statistical Area in 1963.

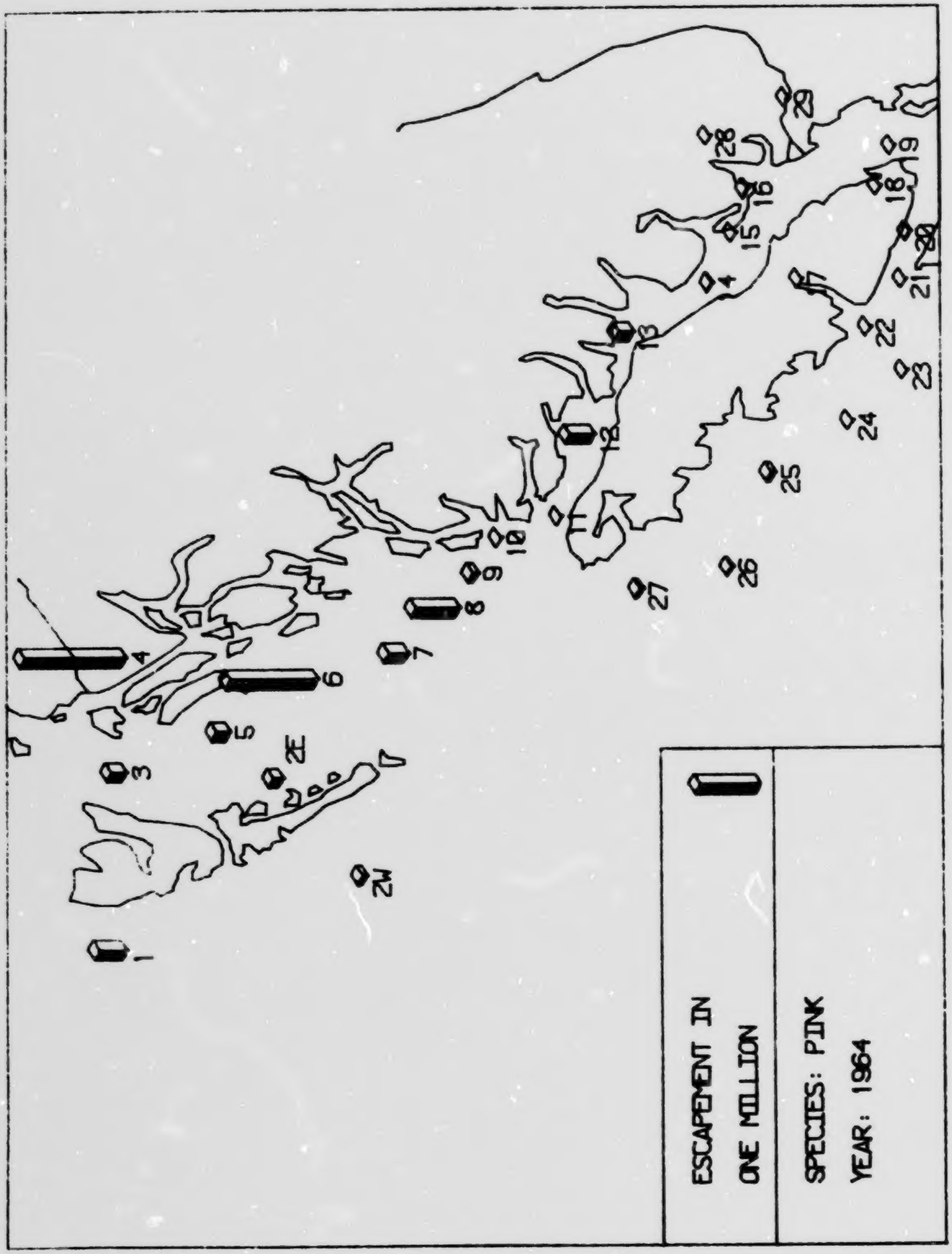
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1964

Fig. C14. Escapement of pink salmon by Statistical Area in 1964.

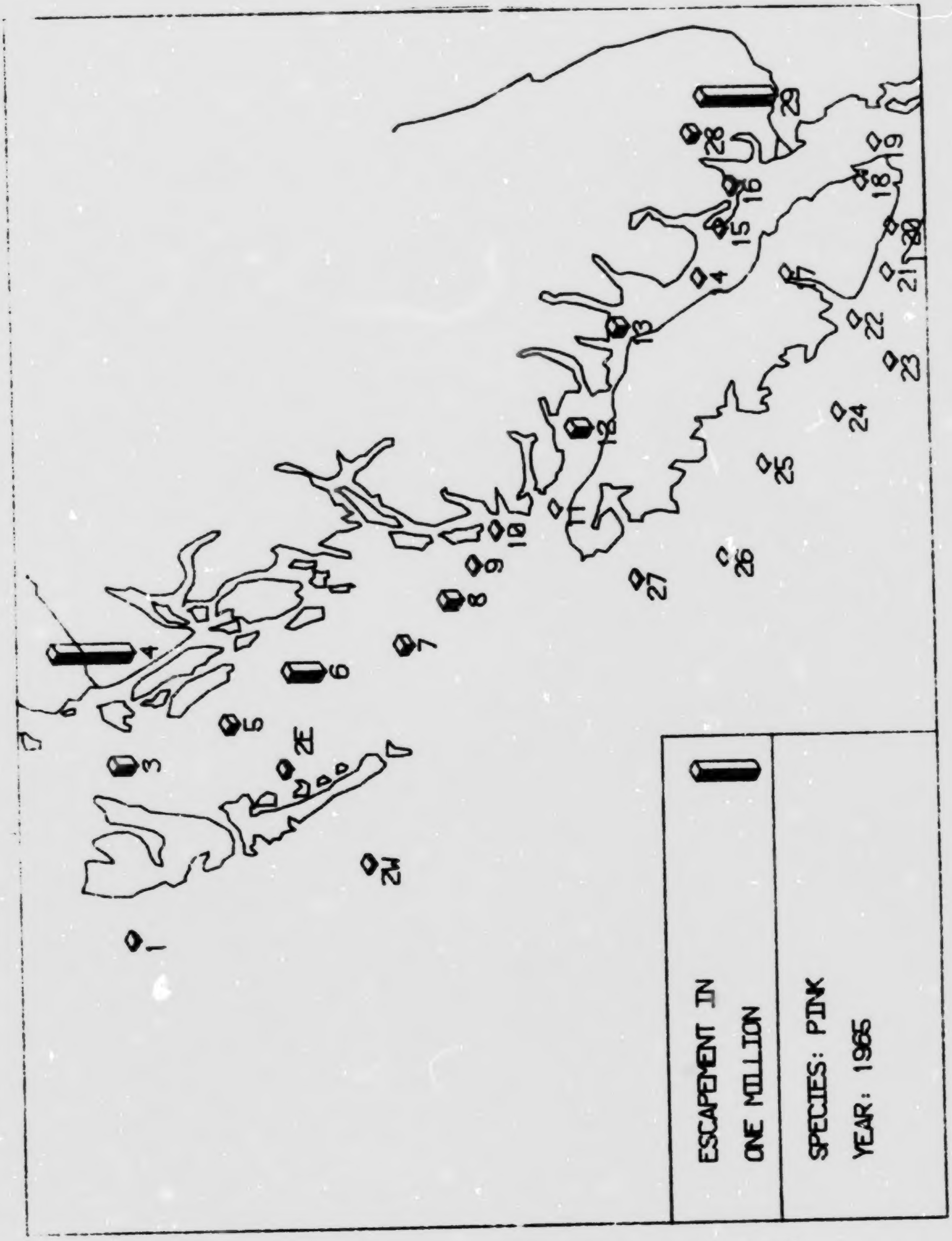
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1965
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C15. Escapement of pink salmon by Statistical Area in 1965.

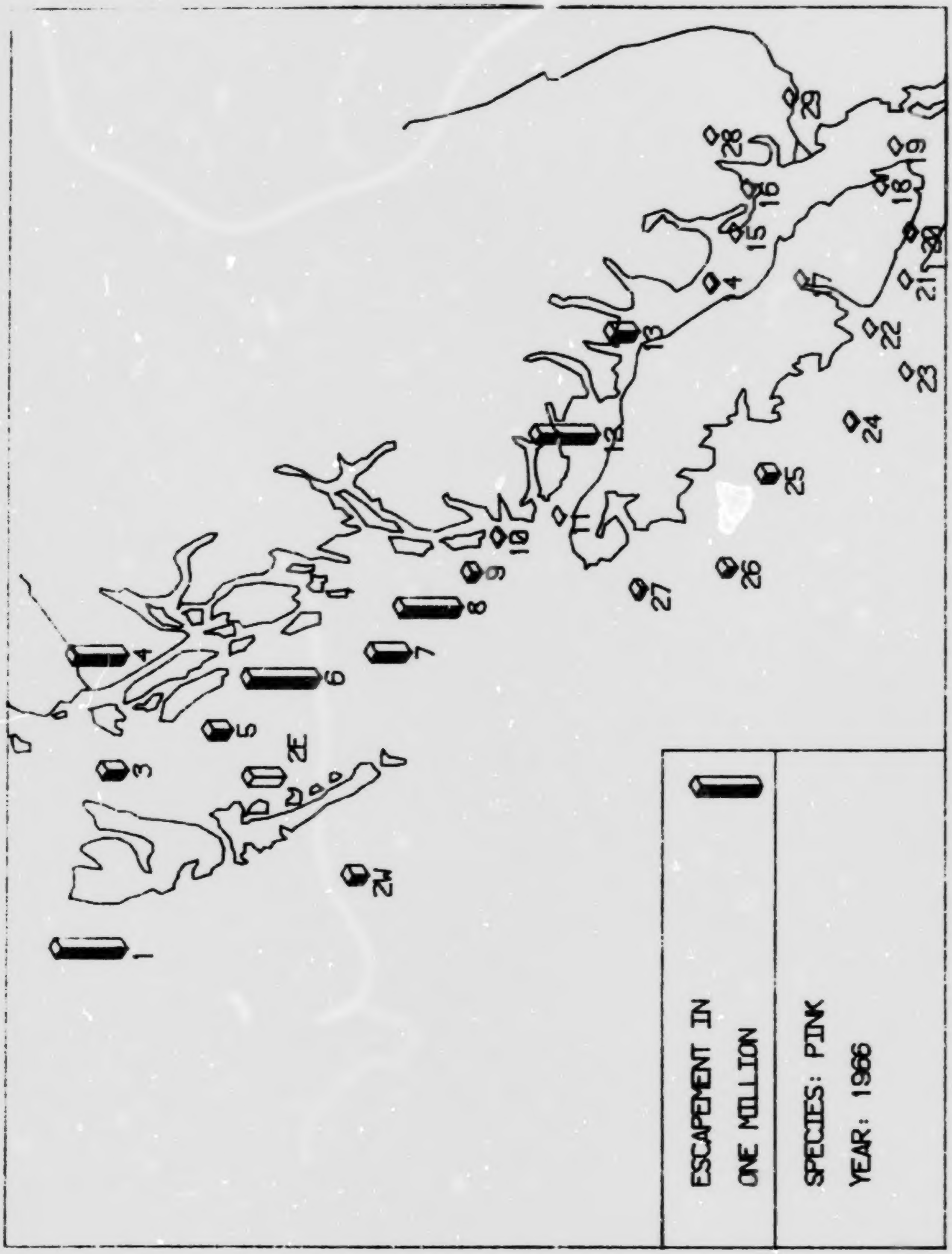
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1966
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C16. Escapement of pink salmon by Statistical Area in 1966.

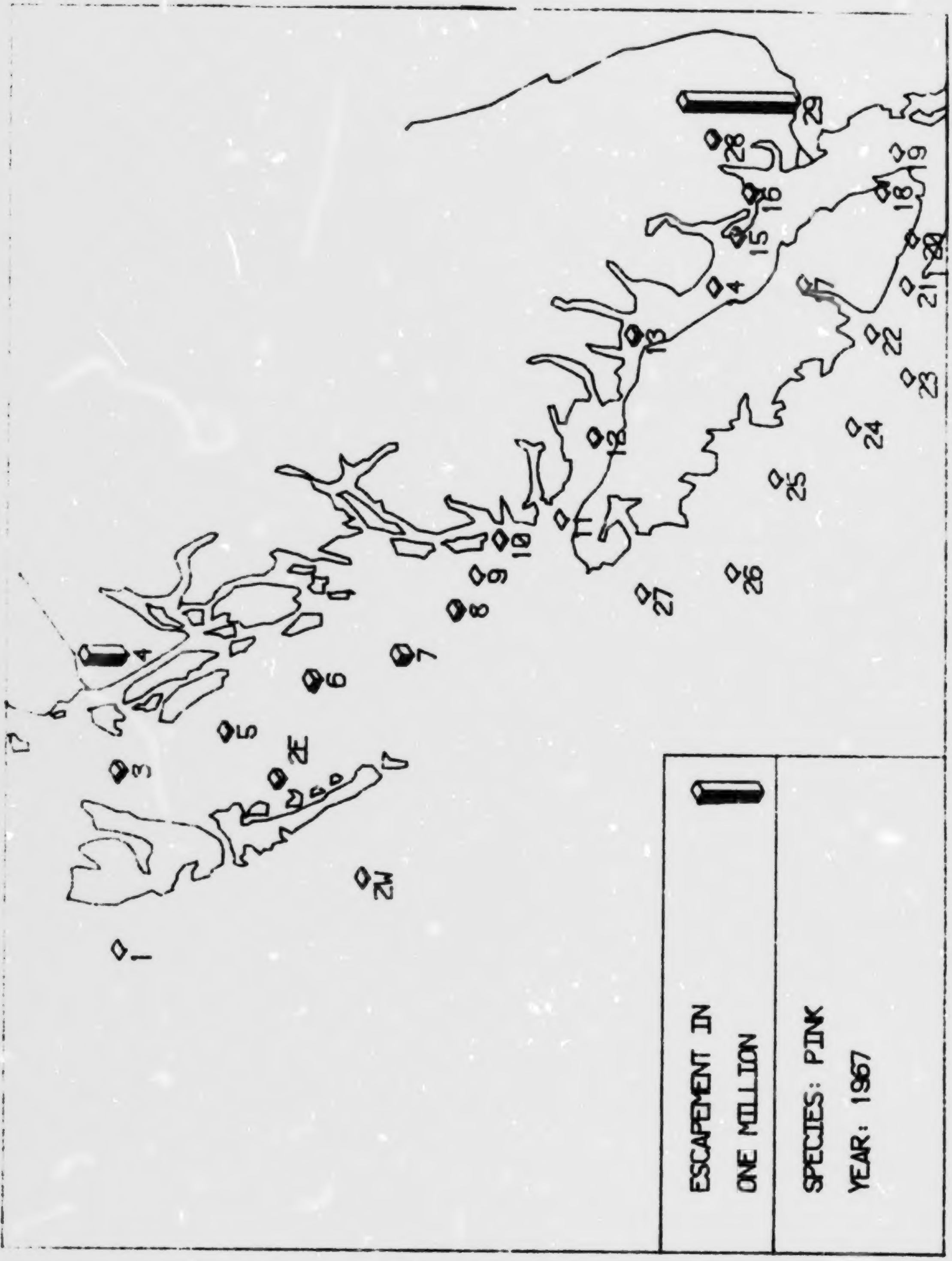
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1967
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C17. Escapement of pink salmon by Statistical Area in 1967.

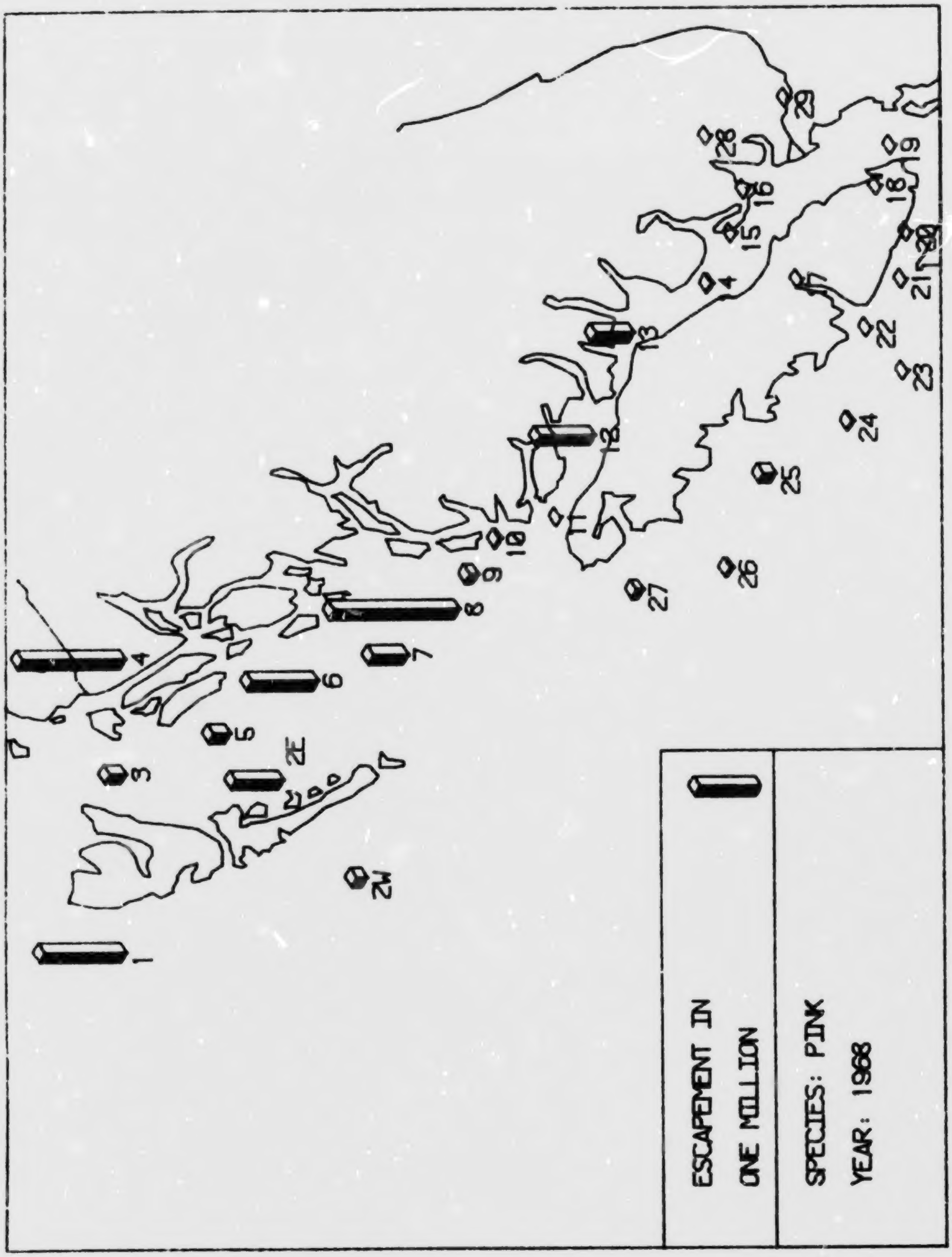
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1968
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C18. Escapement of pink salmon by Statistical Area in 1968.

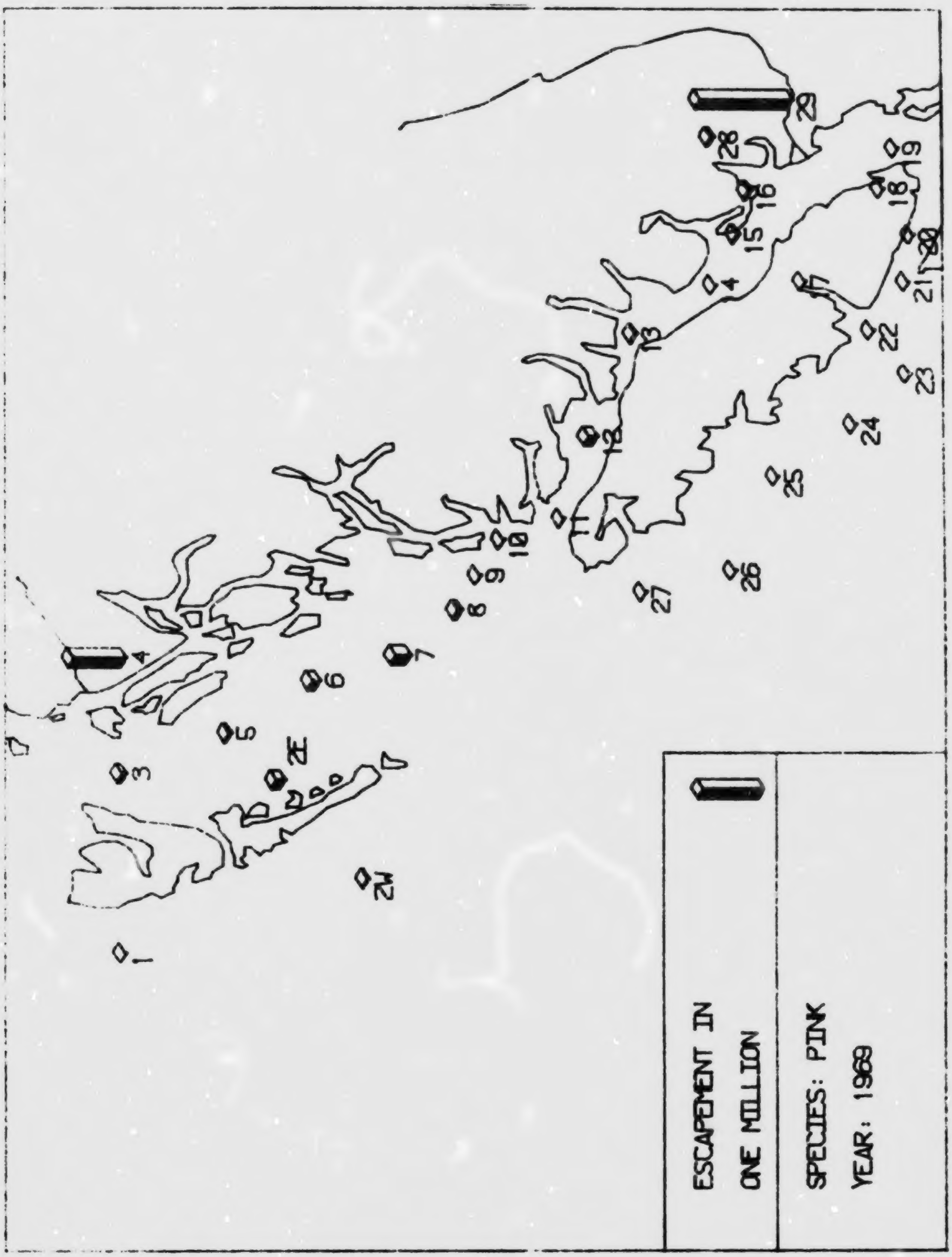
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1969
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C19. Escapement of pink salmon by Statistical Area in 1969.

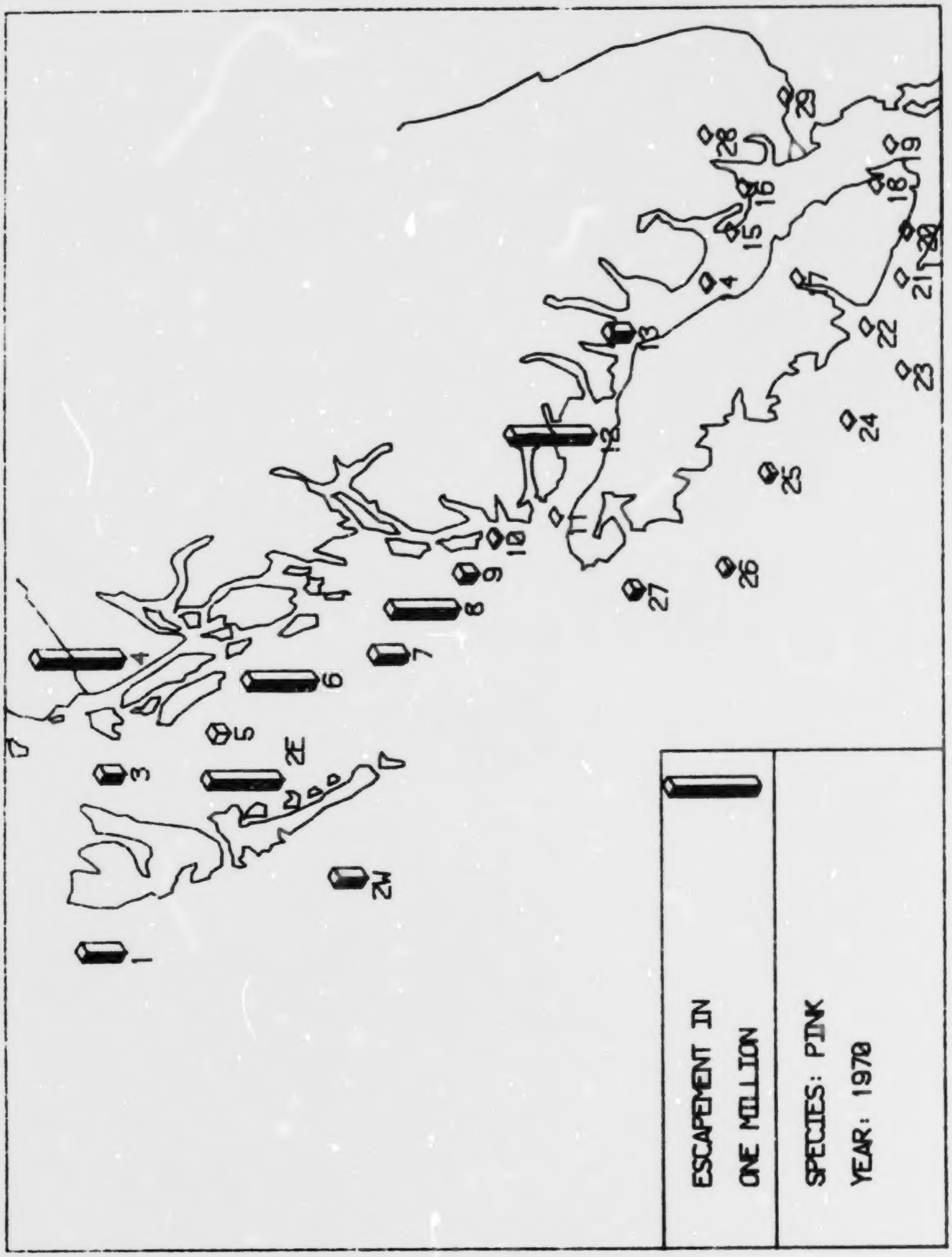
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1970
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C20. Escapement of pink salmon by Statistical Area in 1970.

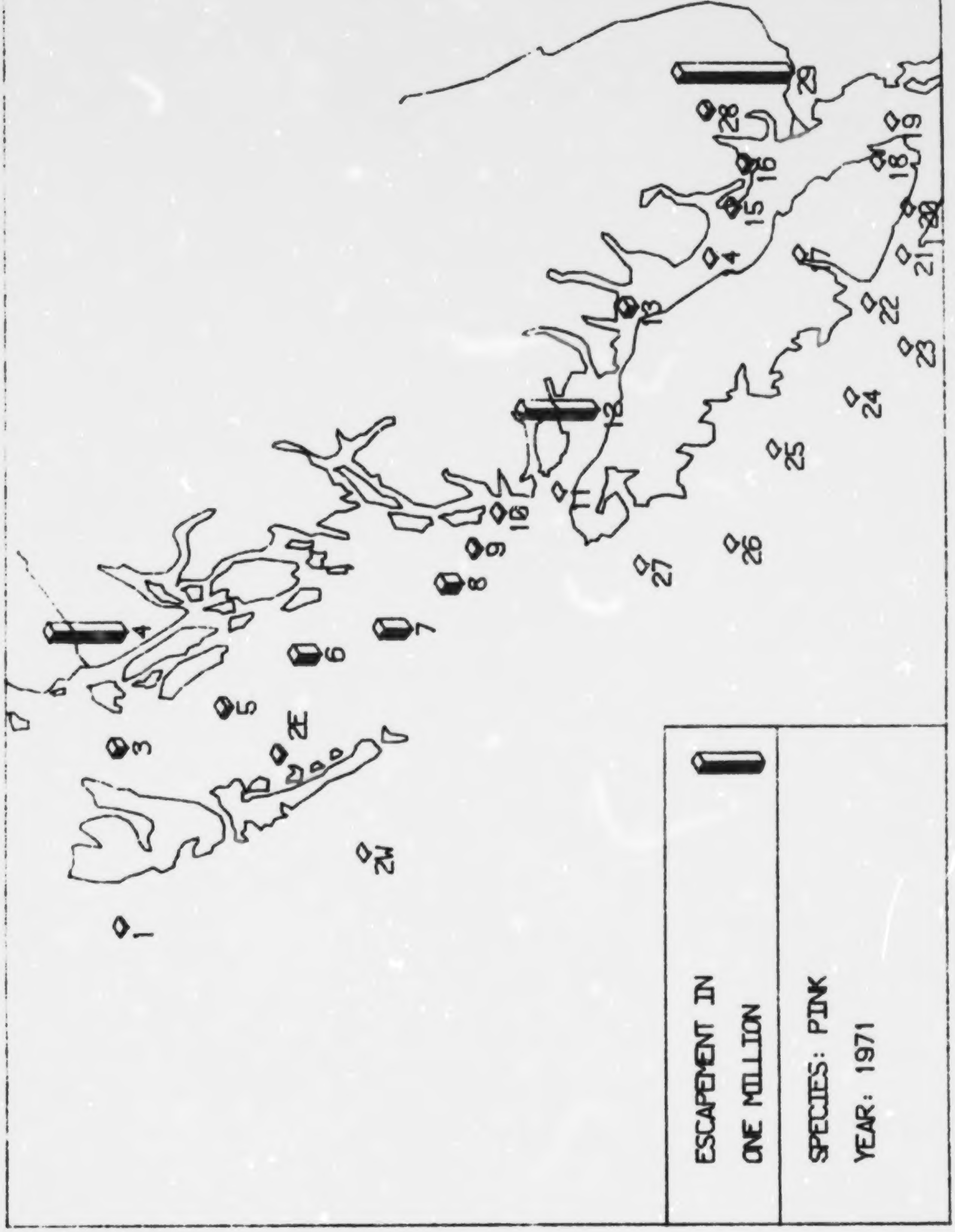
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1971

Fig. C21. Escapement of pink salmon by Statistical Area in 1971.

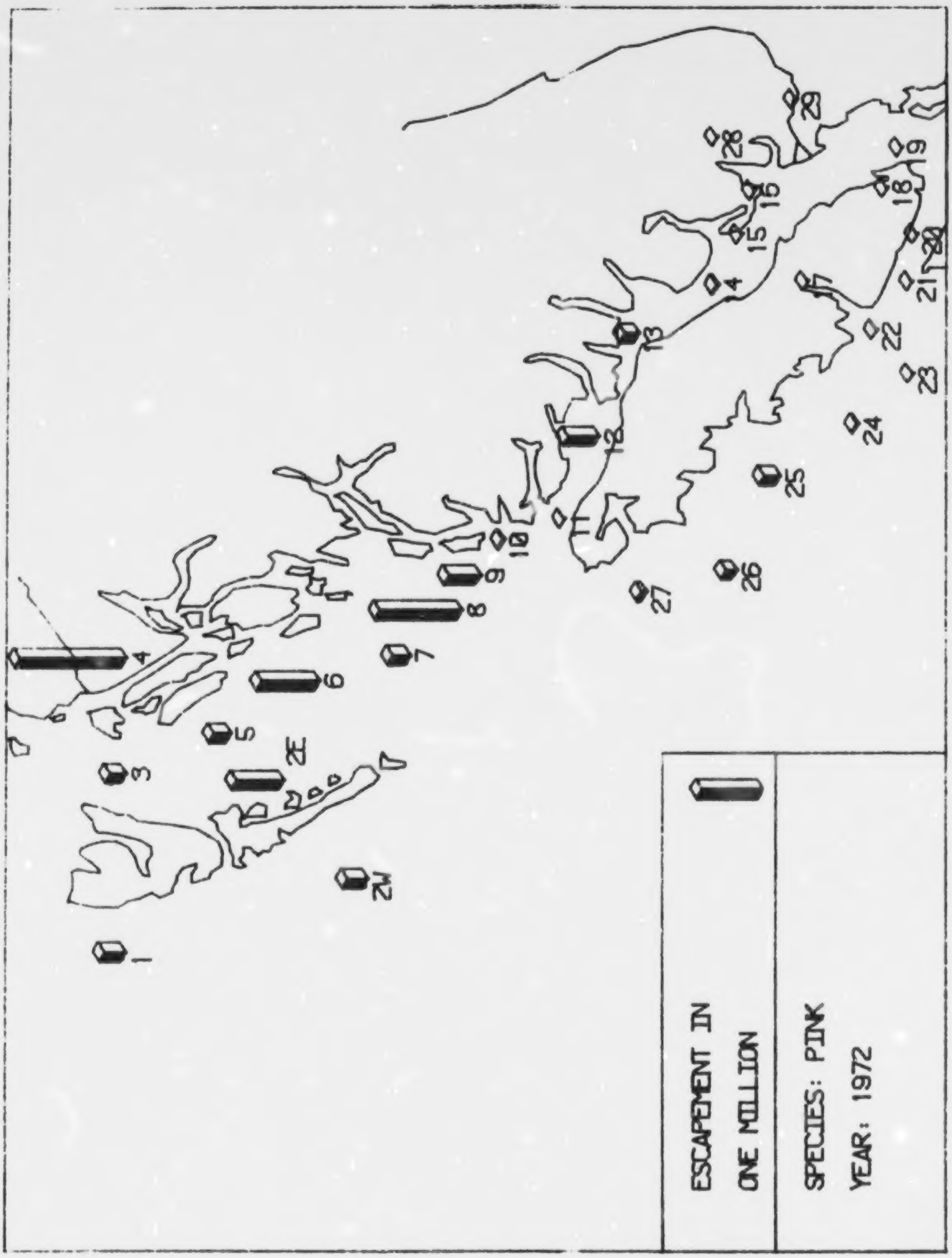
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1972

Fig. C22. Escapement of pink salmon by Statistical Area in 1972.

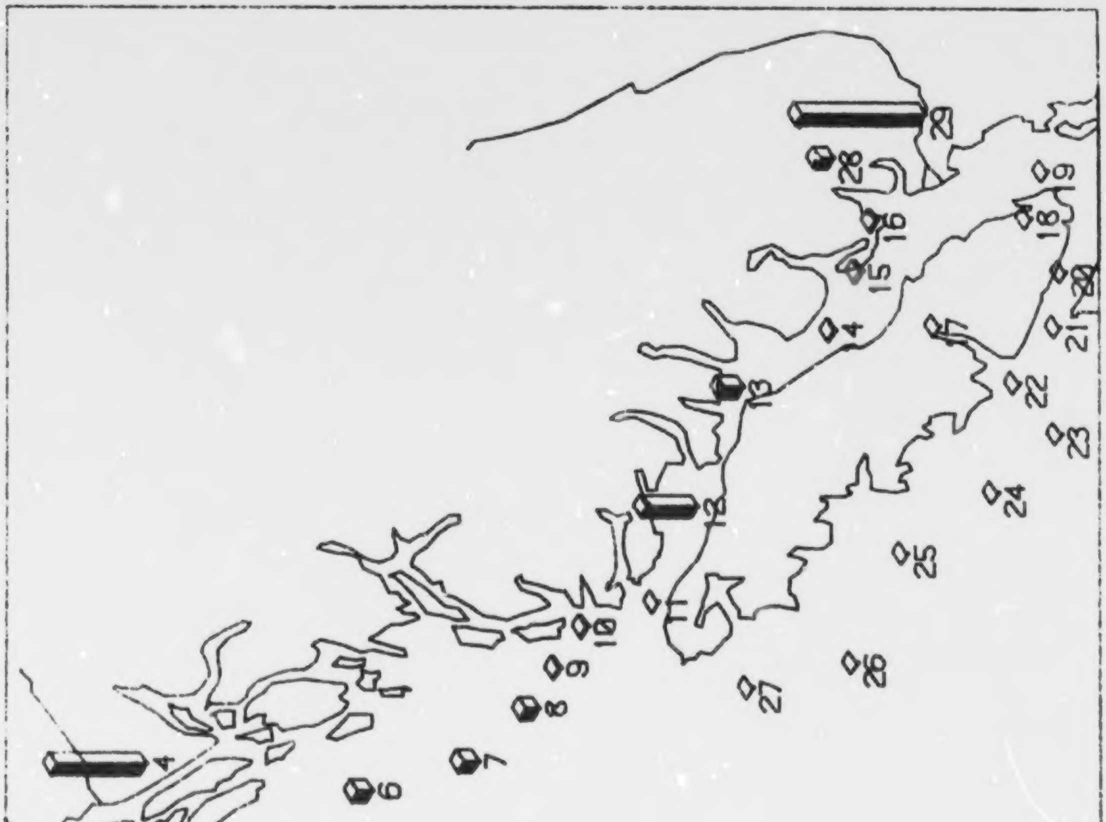
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1973

Fig. C23. Escapement of pink salmon by Statistical Area in 1973.

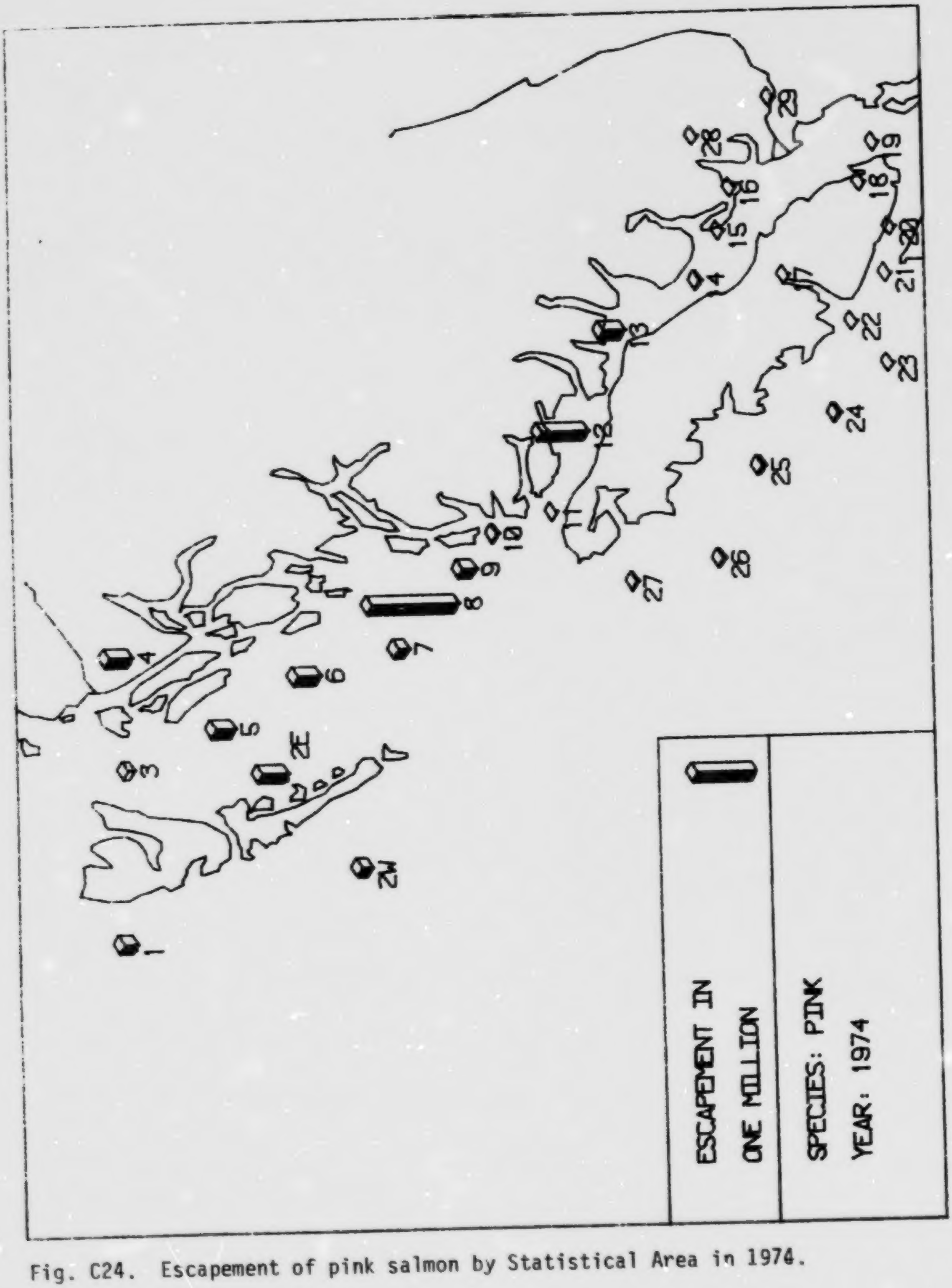
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1974
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C24. Escapement of pink salmon by Statistical Area in 1974.

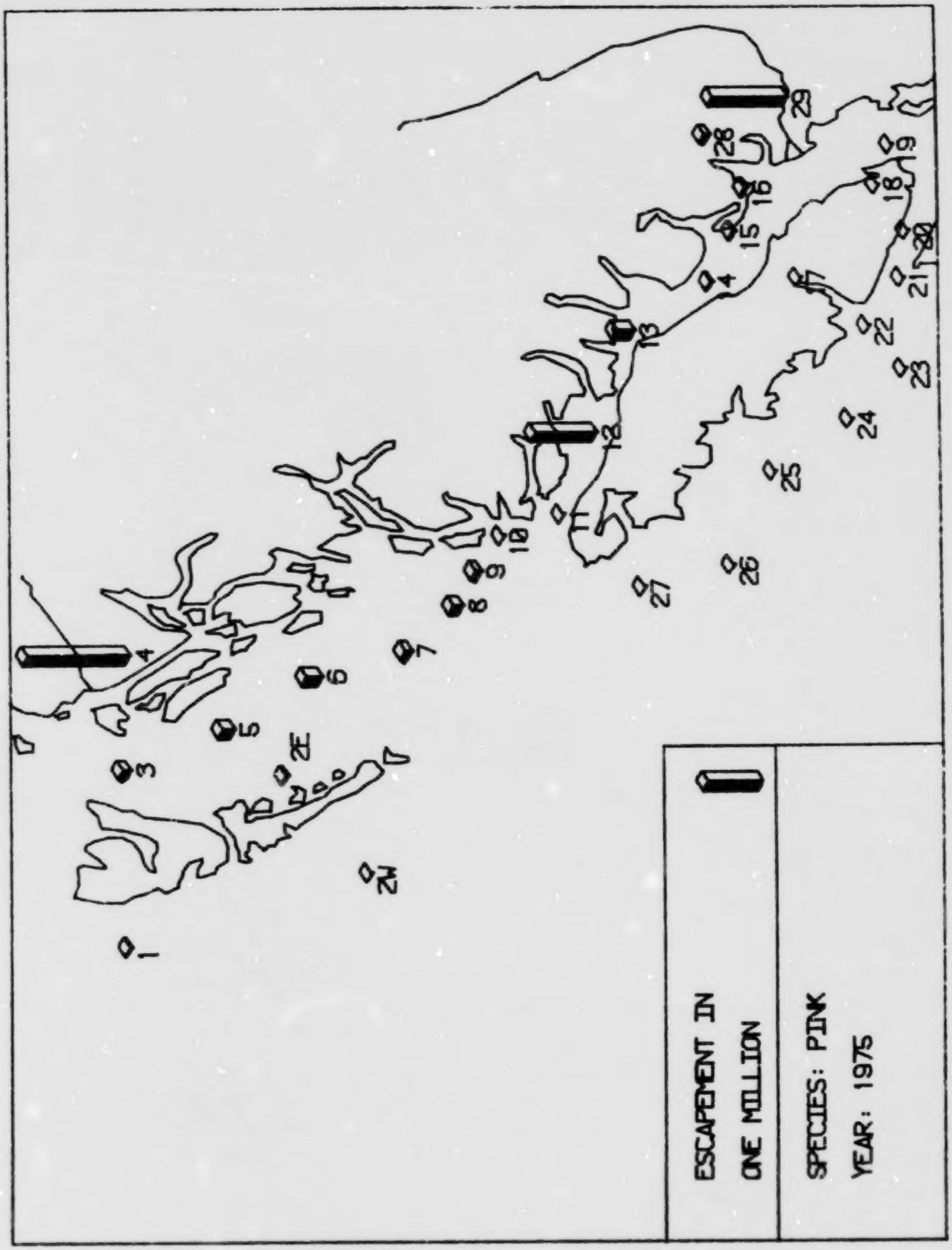
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1975
1
2W
2E
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C25. Escapement of pink salmon by Statistical Area in 1975.

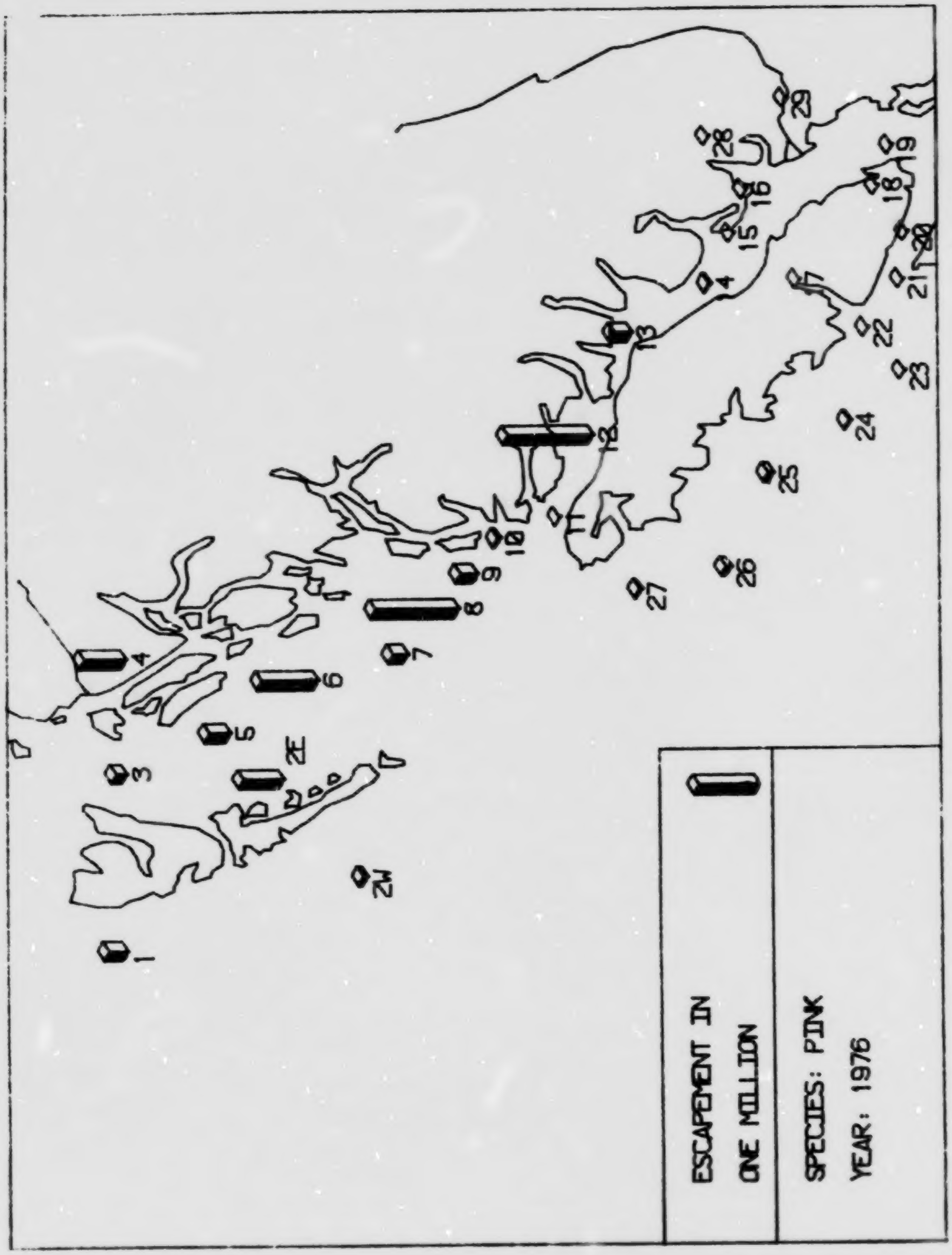
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1976
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C26. Escapement of pink salmon by Statistical Area in 1976.

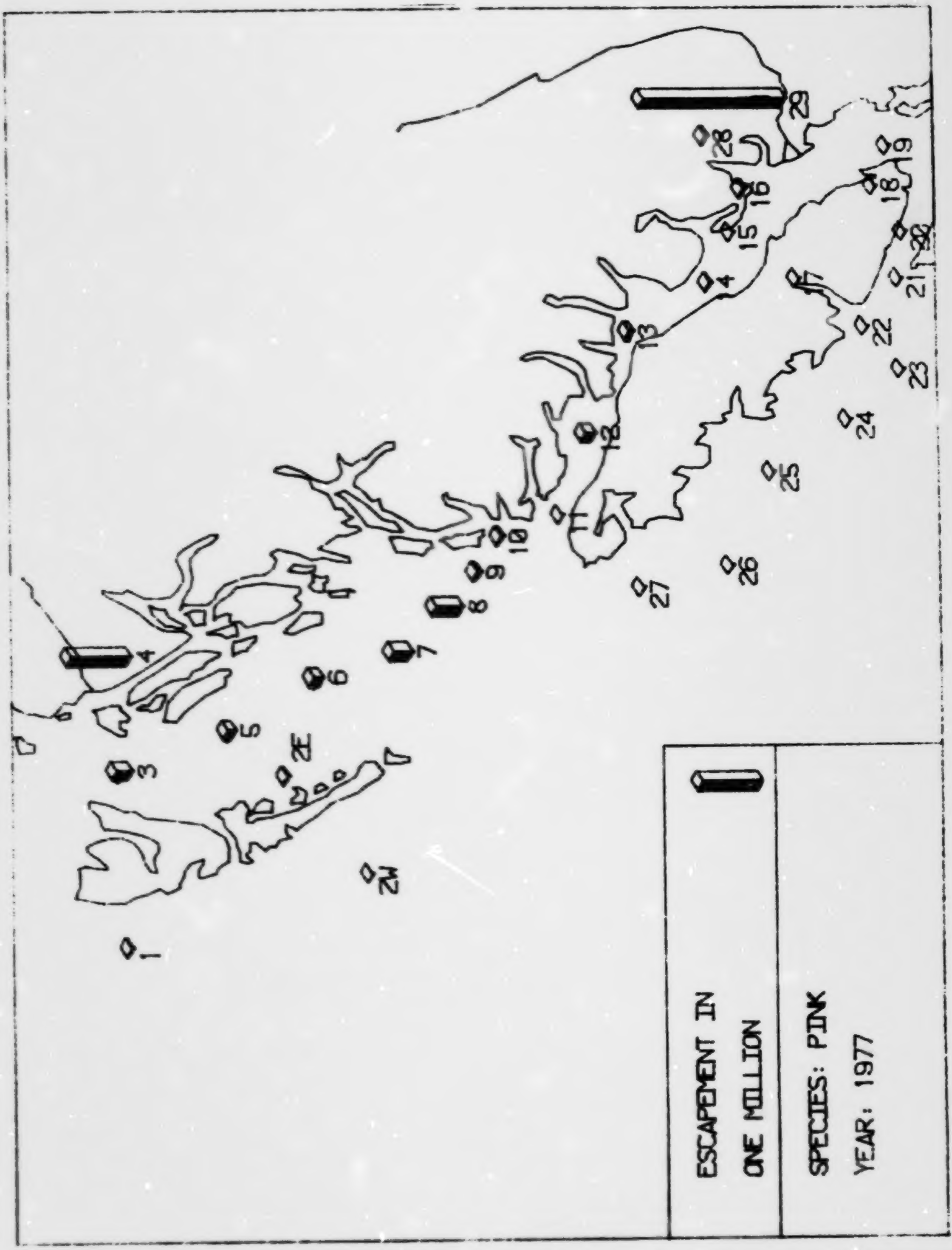
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1977
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C27. Escapement of pink salmon by Statistical Area in 1977.

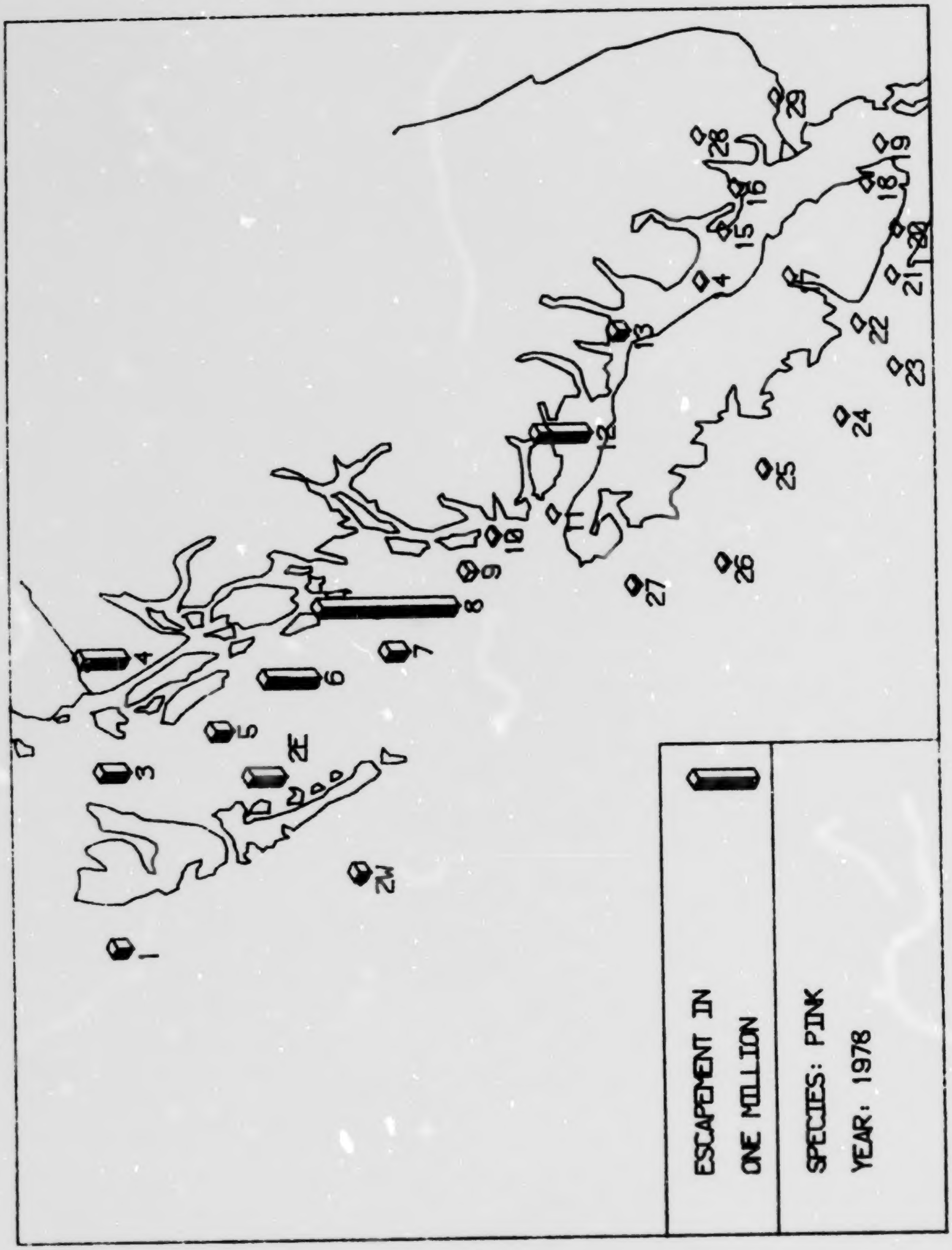
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1978
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C28. Escapement of pink salmon by Statistical Area in 1978.

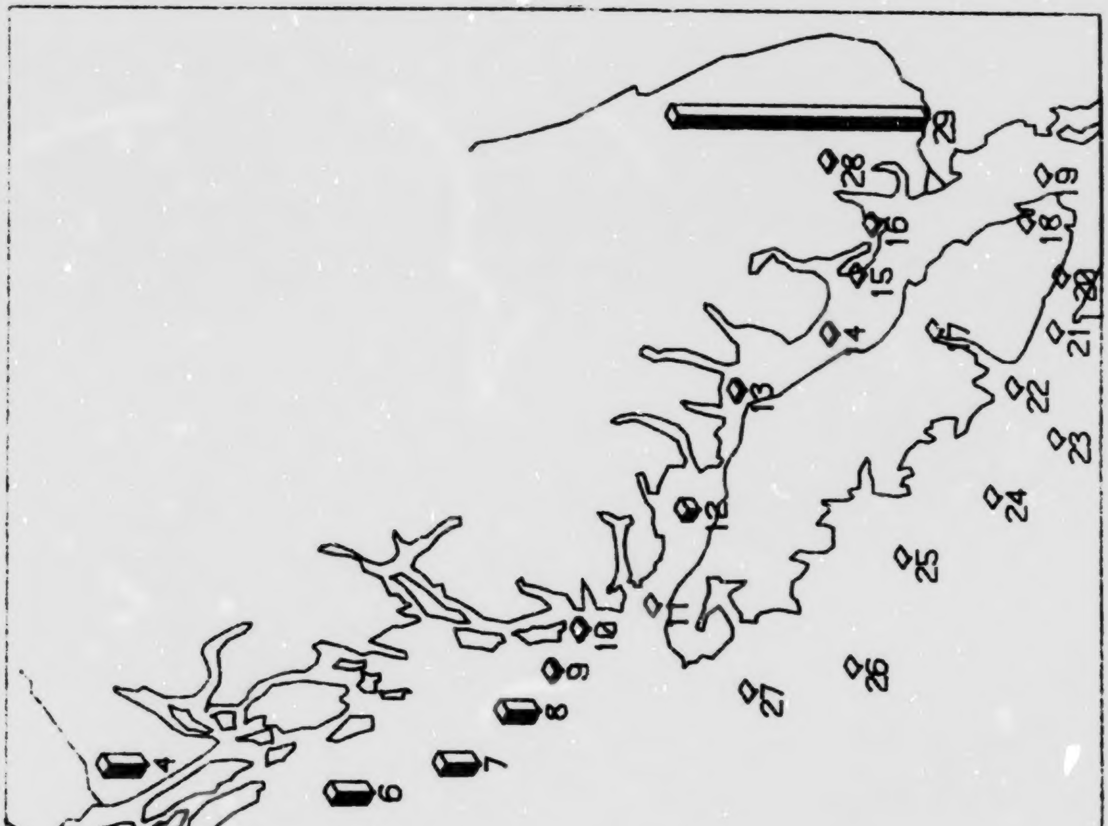
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1979
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C29. Escapement of pink salmon by Statistical Area in 1979.

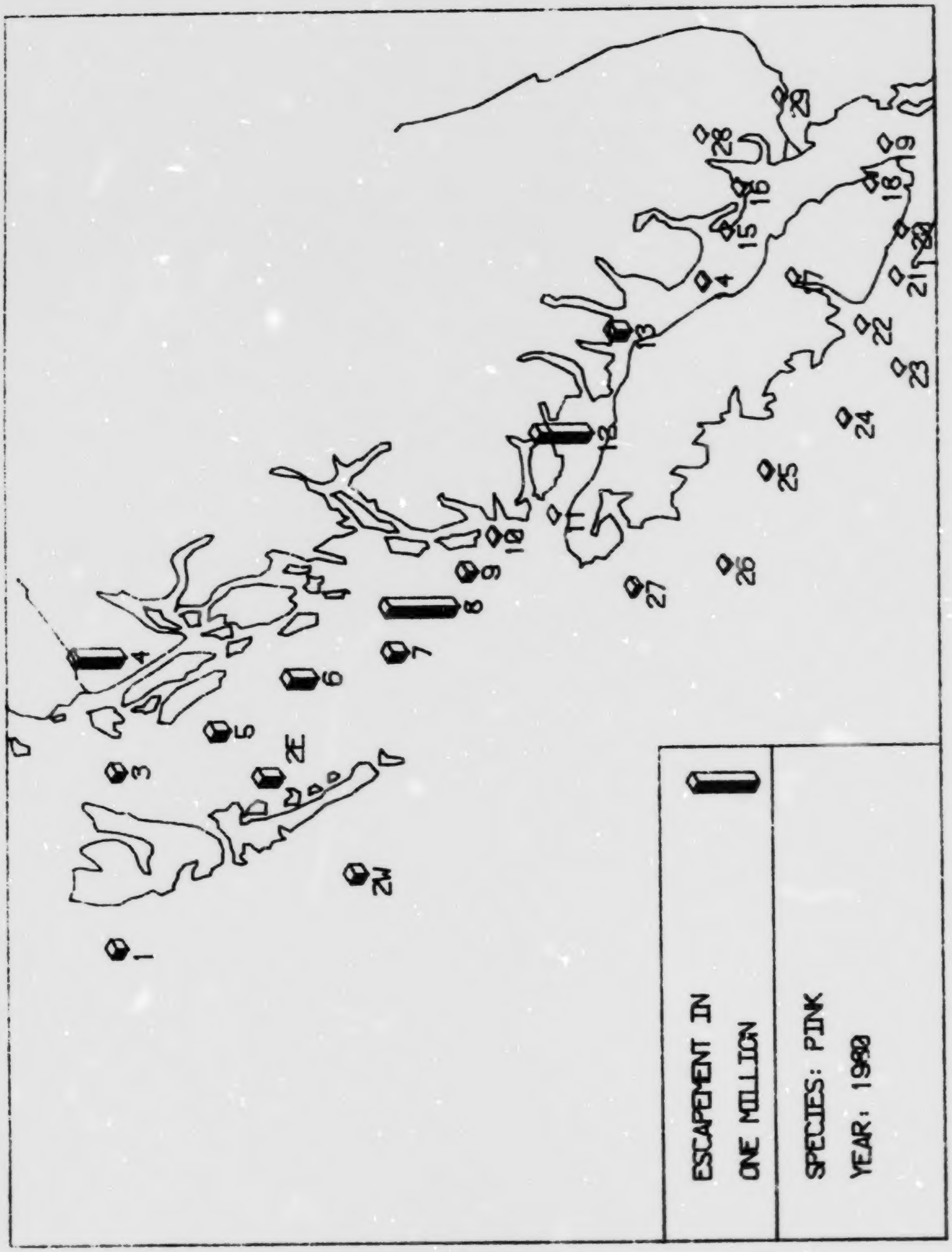
1
2W
2E
3
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1980

Fig. C30. Escapement of pink salmon by Statistical Area in 1980.

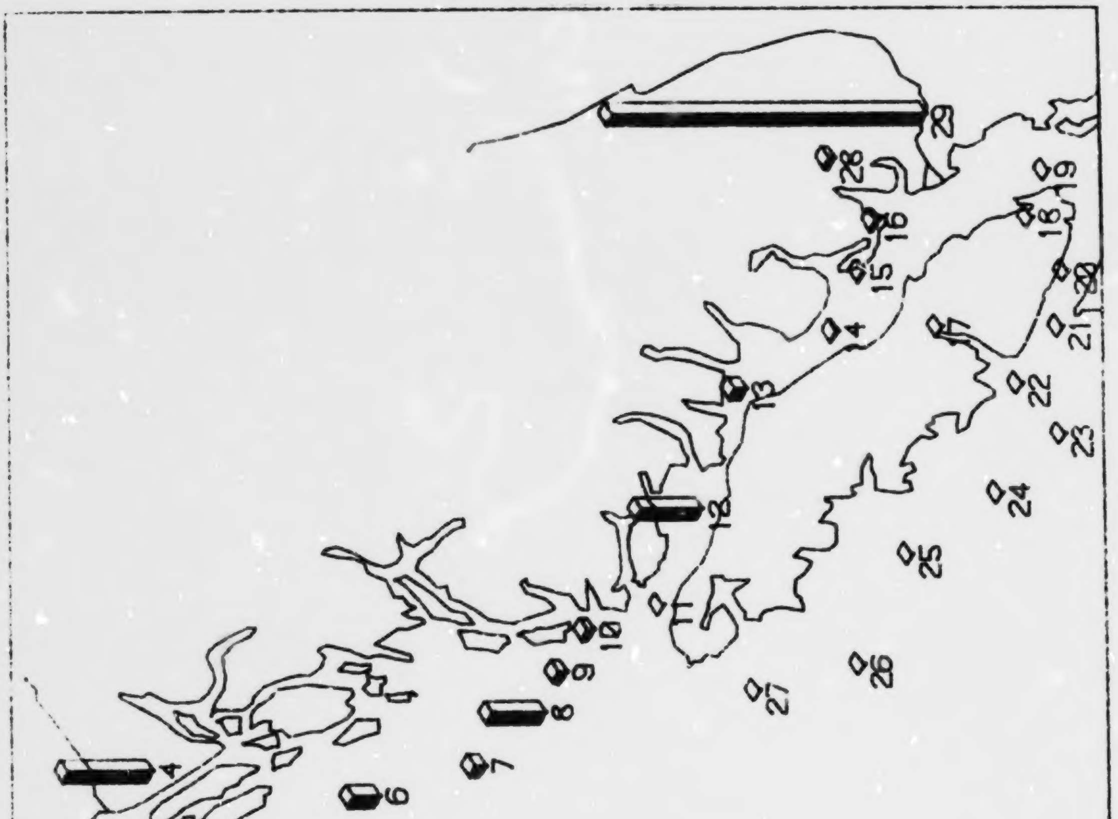
ESCAPEMENT IN
ONE MILLION
SPECIES: PINK
YEAR: 1981
1
2W
3
3E
4
5
6
7
8
9
10
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Fig. C31. Escapement of pink salmon by Statistical Area in 1981.